WEST VIRGINIA GEOLOGICAL SURVEY

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PLATE I.—View from top of Stony Ridge looking south aeross city of Bluefield. Foreground is Bluefield Group. Greenbrier extends from roundhouse to tallest building at left, followed by Maecrady and by Pocono which make low ridge to right of white (Bailey) building. Devonian forms south slope of ridge followed by St. Clair Fault through South Bluefield. From fault to top of East River Mountain in rear roeks range from Beekmantown to White Medina. (Photo. by Palmer & Fowler).

WEST VIRGINIA

GEOLOGICAL SURVEY

Mercer, Monroe, and Summers Counties

By

DAVID B. REGER, Assistant Geologist.

Assisted by

PAUL H. PRICE

I. C. WHITE, State Geologist.

1926

WHEELING NEWS LITHO. CO.
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WM. F. PROUTY (to July 1, 1925) ..... *Paleontologist*

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MARIE STENGER AZURE ..... *Stenographer*

LETTER OF TRANSMITTAL

To His Excellency, Hon. Howard M. Gore, Governor of West Virginia, and President of the West Virginia Geological Survey Commission:

SIR:

I have the honor to transmit herewith the Detailed County Report and accompanying maps, topographic and geologic, covering the area of southern Mercer, eastern Summers, and the entire county of Monroe. This large area has been very carefully studied by Assistant Geologist David B. Reger, the author of this report who has with great skill accomplished what had never been heretofore attempted; viz., a detailed classification of the Mississippian deposits which in larger thickness immediately underlie the true Coal Measures, and themselves often contain seams of coal, some of which Mr. Reger has been able to trace and correlate over a wide area.

Mr. Reger also succeeded in identifying over a large area in these counties several important limestone beds in the great Mauch Chunk Series, some of which, like the Avis Limestone, will prove of much economic value. By means of fossils and stratigraphy he also succeeded in subdividing the great mass of the Greenbrier Limestone into several distinct members which he has correlated with some important formations in other States.

In the study and classification of the very ancient formations brought to the surface by a great fault along the eastern border of Mercer and Monroe Counties, Mr. Reger was fortunate in having the assistance and advice of Dr. Wm. F. Prouty, an accomplished geologist and paleontologist from the University of North Carolina who had studied these older formations in Alabama, Tennessee, and Maryland, and hence was very familiar with their fossils and other characteristics.

Mr. Reger in his preface to this volume has given proper credit to the help received from the several parties who aided him in its preparation and publication.

Very respectfully,

I. C. WHITE, *State Geologist.*

Morgantown, W. Va., December 30, 1925.

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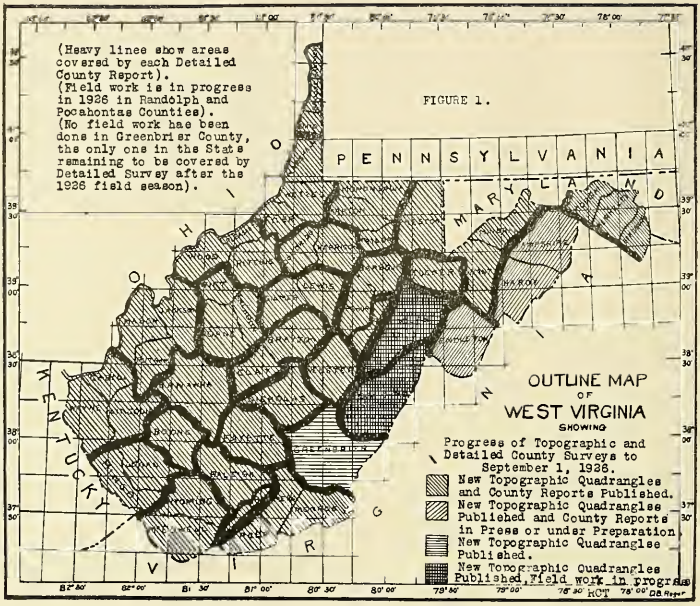
AUTHOR'S PREFACE

This book is a general geological report of Mercer, Monroe, and Summers Counties, West Virginia, exclusive of Rock and Jumping Branch Districts, Mercer County, and Jumping Branch District, Summers County. The three districts excepted have been previously studied by C. E. Krebs and D. D. Teets, Jr., their work having been already published by the Survey in the Report on Raleigh County and the Western Portions of Mercer and Summers Counties (1916). Their investigation in these districts, however, principally concerned the coals which cover only part of the districts, and hence the author, in order to make the study complete, has remapped in more detail the areas of Mississippian outcrops, and at the same time has redrawn the structure maps on the Avis Limestone instead of the No. 3 Pocahontas Coal. With these and a few other minor corrections and additions the geologic maps of the three districts are republished as integral parts of the present county maps. In the case of the written text only important summaries of estimated coal reserves have been reproduced.

As shown by the Table of Contents this Report contains a short chapter of Historical and Industrial data, a chapter on Physiography, ten chapters on Geologic History, Structure, and Stratigraphy, four chapters on Mineral Resources, and two chapters on Paleontology, as well as an Appendix giving all available spirit-level bench marks and railroad levels in the three counties.

In a separate Atlas, Maps I and II show the topography and geology, respectively, of Mercer County, Maps III and IV show the same data for Monroe, and Maps V and VI for Summers. On all these maps the topographic base is assembled and photolithographed from the standard topographic quadrangles as surveyed and published by the United States Geological Survey in cooperation with the West Virginia Geological Survey, certain additions and corrections, principally roads, railroads, and place names, being added by the author. On this corrected base the geologic maps have been drawn.


(Heavy linee show areas covered by each Detailed County Report).
(Field work is in progress in 1926 in Randolph and Pocahontas Counties).
(No field work has been done in Greenbrier County, the only one in the State remaining to be covered by Detailed Survey after the 1926 field season).
FIGURE 1.
PENNSYLVANIA
MARYLAND
OHIO
KENTUCKY
VIRGINIA
OUTLINE MAP OF WEST VIRGINIA SHOWING
Progress of Topographic and Detailed County Surveys to September 1, 1926.
New Topographic Quadrangles and County Reports Published.
New Topographic Quadrangles Published and County Reports in Press or under Preparation.
New Topographic Quadranglse Published.
New Topographic Quadrangles Published, Field work in progress

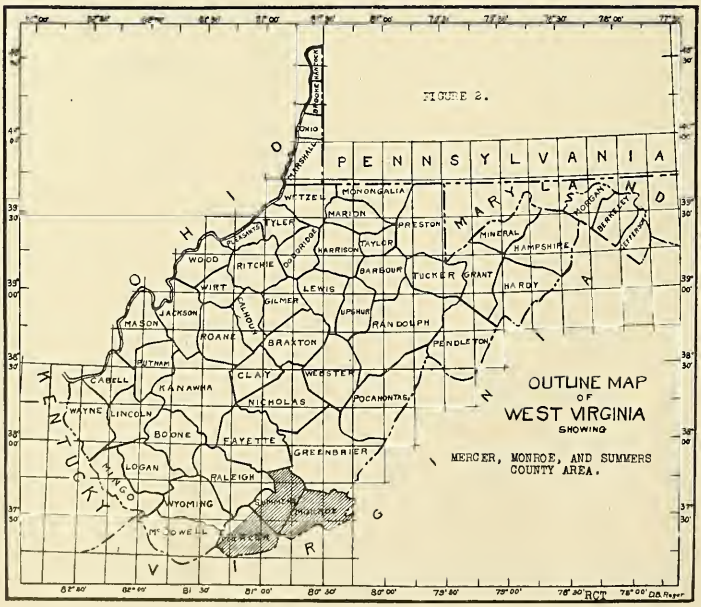


FIGURE 2.
PENNSYLVANIA
MARYLAND
OHIO
KENTUCKY
VIRGINIA
OUTLINE MAP OF WEST VIRGINIA SHOWING
MERCER, MONROE, AND SUMMERS COUNTY AREA.

The outcropping rocks of these three counties embrace a total of about 19,300 feet of strata some of which contain important minerals like coal and iron and all of which are of scientific interest. In the Pennsylvanian, Devonian, Silurian, and Ordovician the local beds are the prototypes of those found in many other areas where they have been abundantly described and hence their study and mapping is more or less a matter of geologic routine. In the Mississippian portion of the column, however, including 6,500 feet of rocks, these three counties and some adjacent territory in the State of Virginia afford an extraordinary development in the way of fossil marine and plant life and clearly defined stratigraphy that is neither fully duplicated nor equalled elsewhere in the whole Appalachian region, there being, among other features, several limestones in the middle of the Greenbrier Series that are local to the two States and that may be regarded as new to science since they have never been previously studied in detail. These new beds are more than 1,000 feet thick in West Virginia and more than 1,700 feet in Virginia and hence would alone be worthy of an elaborate report. In the Mauch Chunk Series, also, it has been necessary to name and describe for the first time a vast number of minor subdivisions, many of which can be traced for hundreds of miles and few of which have been studied in detail northeast of the Kentucky-Virginia line, while at the same time only the lower portion of this series appears to exist west of southwest Virginia. Naturally the proper exposition of all this Mississippian stratigraphy, much of which has hitherto been described only in skeleton form, has commanded the major attention and has much delayed the final publication of this Report, since it has involved not only much local work but also a trip of comparison from southern Tennessee to northeastern Pennsylvania. Naturally, also, the work of mapping areal geology and structure in the local area has suffered to some extent, the stratigraphy being regarded as the most important.

In the study of the floral aspects of the Mississippian the author has had the invaluable cooperation of Dr. David White, Senior Geologist, United States Geological Survey, who spent a week in the field and whose descriptions of his own and the

author's plant collections in the local area it was hoped to publish in Chapter XVII. Unfortunately it has not been possible for Dr. White to complete these studies and hence there appears in Chapter XVII only a preliminary statement on "General Features of the Mississippian Floras of the Appalachian Trough".

On the invertebrates of the Mississippian an equally valuable and possibly more laborious study has been undertaken by Dr. George H. Girty, Geologist, United States Geological Survey, who also spent a week in the field and whose work it was intended to publish in Chapter XVIII. Other official duties, however, made it impossible for Dr. Girty to complete this work and hence only type localities or representative lots of fossils have been given in preliminary form.

The author now has under way a special volume on the stratigraphy of the Mississippian in the Appalachian States which is also designed to include the floral studies of Dr. David White and the faunal work of Dr. Girty, not only in the local counties of the present Report but also in the much wider Appalachian field insofar as they may be pertinent.

Dr. William F. Prouty of the University of North Carolina and lately of the West Virginia Geological Survey Staff spent three or four weeks in the field studying the faunas of the Devonian, Silurian, and Ordovician, his identifications being published along with the stratigraphy of the beds in Chapters V, X, XI, and XII, with a review and discussion by himself in Chapter XVIII.

The attention of the cement and limestone trade is called to Chapter XIV which is especially devoted to this industry and in which the possibilities of the three counties are described.

The author spent the field season of 1922 in gathering data for this Report and also a portion of the season of 1924. Valuable aid was afforded by Mr. Paul H. Price, Field Assistant, who spent three weeks in the field in 1924, made the final draft of the maps and figures and performed other duties. Mr. R. C. Tucker, Engineer and Field Assistant, proof-read the volume and prepared the Index. Mrs. George R. Farmer, Mrs. Marie Stenger Azure, Miss Jessie Ralphsnyder, and Miss Nina Foreman transcribed much data and copied the manuscript.

The chemical and calorific tests, except as otherwise specified in the text, were made by B. B. Kaplan, Chemist, in his usual careful manner.

It is manifestly impossible to make detailed mention of the many citizens of the three counties who most generously furnished local guidance, often at personal inconvenience to themselves, while field work was in progress, but to all these general acknowledgment is made both on behalf of the author and in the name of the State whose interest was served. By way of exception, however, special acknowledgment is due to Mr. W. R. Crenshaw, President of the Bluefield Real Estate Board, whose extraordinary interest in nature and whose consequent wide acquaintance with the region around Bluefield and whose many acts of courtesy to the author and to other visiting scientists are remembered with much pleasure.

Finally, the author expresses his obligation to Dr. I. C. White, State Geologist, whose constant supervision, most kindly criticisms, and instructive suggestions have added greatly to the value of this Report.

DAVID B. REGER.

Morgantown, W. Va., December 28, 1925.

ERRATA.

Page 10, line 17 from bottom, for "Richomnd", read "Richmond".
Page 25, line 2 from top, for "2000 foot", read "2000-foot".
Page 51, line 13 from bottom, for "mining", read mineral".
Page 54, line 3 from bottom, for "Indian Springs", read "Indian Mills".
Page 66, line 27 from bottom, delete "clay".
Page 69, top line, for "Bauley", read "Gauley".
Page 83, line 18 from bottom, for "Wolf Creek District", read "Forest Hill District".
Page 85, line 32 from bottom, for "Burnside Creek" read "Burnsiue Branch".
Page 88, line 25 from top, for "Middleton", read "Middle".
Page 88, line 25 from bottom, for "Larton", read "Lorton".
Page 115, line 5 from bottom, for "feldspatic", read "feldspathic".
Page 120, line 14 from top, for "latter", read "later".
Page 123, line 4 from bottom, for "1991", read "1901".
Page 138, line 5 from bottom, for "p. 30", read "p. 36".
Page 147, top line, for "Virgina", read "Virginia".
Page 161, line 13 from top, for "Marellus", read "Marcellus".
Page 172, line 3 from bottom, for "Maunch", read "Mauch".
Page 190, line 2 from top, for "Bluestone", read "Hinton".
Page 191, line 2 from top, for "Buestone", read "Bluefield".
Page 192, delete "Intervals. Feet", in Waugh Siding Seetion.
Page 193, line 8 from top, for "ge", read "age".
Page 193, line 14 from top, for "it", read "its".
Page 194, line 4 from bottom, for "Fairgrounds", read "Fair-Grounds".
Page 197, line 25 from top, for "Shale, Upper Tophet", read "Shale, Lower Tophet".
Page 204, line 20 from top, for "Manard", read "Menard".
Page 209, line 21 from bottom, for Total "225", read "255".
Page 209, line 6 from bottom, for "Coelspira", read "Coelospira".
Page 210, line 16 from bottom, for "Conrad", read "Emmons".
Page 213, line 6 from top, for "Railwaay", read "Railway".
Page 216, line 13 from bottom, for "overtrusts", read "overthrusts".
Page 222, line 26 from top, for "Greenbrier Limestone", read "Greenbrier Series".
Page 224, line 24 from bottom, for "Uuion", read "Union".
Page 226, line 8 from top, for "Poono", read "Pocono".
Page 235, line 4 from top, for "altenata", read "alternata".
Page 235, line 17 from bottom, for "tessalatus", read tesselatus".
Page 239, line 17 from bottom, for "Group", read "Groups".
Page 240, line 3 from top, for "Falls Mill", read "Falls Mills".
Page 240, line 8 from top, for "Sandtone", read "Sandstone".
Page 250, line 6 from top, for "Lot 195" read "Lot 196".
Page 260, for "14. Shale, Avis", read "14. Shale, Upper Avis".
Page 277, line 18 from bottom, for "fanua", read "fauna".
Page 283, line 17 from bottom, for "Brnach", read "Branch".
Page 287, line 7 from bottom, for "and described as generally massive, me-" read "and the No. 1 Pocahontas Coal, com-".
Page 406, line 5 from top, for "1730", read "1730'".
Page 406, line 8 from top, for "tion 1730'.' its weathered surface having a gray color. On" real "tion 1655' B., coming 25 feet above Coal Exposure No. 782 on".
Page 527, line 21 from bottom, for 'malie", read "melie".
Page 632, line 16 from bottom, for "Herbertella", read "Hebertella".
Page 728, line 16 from bottom, for "Hawkin" read "Hawkins".
Page 770, under No. 25, add sample No. "599R".
Page 796, line 4 from top, for "limestone", read "limestones".
Page 833, under Lot Number, W. V. G. S., change "238" to "239".
Page 833, under Lot Number 244 (W. Va. G. S.), column headed "Member or Zone", for "Cooney", read "Coney".
Page 881, line 20 from bottom, add "of" after "southeast".
Page 896, line 11 from top, add "3,058.60" at end of line.
Page 859, line 3 from bottom, for "Platycerass aff. P. Crytolites", read "Platyceras aff. P. cyrtolites".
Page 860, line 3 from bottom, for "Beck-", read "Beek-".
Page 865, line 22 from top, for "nickelesi", read "nicklesi".
Page 869, bottom line follows "394-5." line in table at top of page.
Page 871, line 2 from top, for "Elevation", read "Elevations".
Page 872, line 7 from top, for "Moroa", read Mora".
Page 918, under Elevations, Beury and Dimmock, for "869", read "868".
Page 919, under Elevations, for "Moutcalm", read "Montcalm".
Page 919, under Elevations, Rush Run and Thurmond, for "869", read "868".

PART I.

History and Physiography.

CHAPTER I.

HISTORICAL AND INDUSTRIAL DEVELOPMENT.

LOCATION.

Mercer, Monroe, and Summers Counties, with certain territorial exceptions, comprise the area in this Report. The regions excepted are Jumping Branch and Rock Magisterial Districts, Mercer County, and Jumping Branch District, Summers County, the geology of these three districts having been studied and described by C. E. Krebs[1] in a former Report of the Survey. In the atlas which accompanies the present volume the areal and economic mapping of Mr. Krebs and his assistant, Mr. D. D. Teets, Jr., in the three districts named, has been repeated with certain added details, but in the text only a slight amount of data along Bluestone and New Rivers has been republished.

Considered as a whole, and including the three districts above mentioned, the three counties are situated near the

[1]C. E. Krebs, Raleigh County and Western Portions of Mercer and Summers Counties, W. Va. Geological Survey; 1916.

extreme southern end of West Virginia, being included between the parallels of 37° 13′ and 37° 53′ North Latitude, and the meridians of 80° 13′ and 81° 22′ West Longitude from Greenwich. In its general appearance on the map this territory has the form of a rough polygon, the longer axis of which, extending from the eastern tip of Monroe County to the western corner of Mercer, is approximately 70 miles long, while the shorter dimension, reaching from the northern edge of Summers County southeastward to the Virginia State line, is 32 miles.

Mercer County, occupying the southern third of the area, is bounded on the north by Wyoming, Raleigh, and Summers Counties, West Virginia; on the east by Summers County, West Virginia, and Giles County, Virginia; on the south by Giles and Bland Counties, Virginia; and on the west by Tazewell County, Virginia, and McDowell, Wyoming, and Raleigh Counties, West Virginia. It is drained mainly by East River and Bluestone River, both tributary to New River, and in small part by the parent stream.

Monroe County, comprising the southeastern third of the territory, is bounded on the north by Summers and Greenbrier Counties, West Virginia; on the east by Alleghany and Craig Counties, Virginia; on the south by Craig and Giles Counties, Virginia; and on the west by Giles County, Virginia, and Summers County, West Virginia. It is mostly drained by New River and Greenbrier River, the latter being tributary to the former, but the streams of its southeastern corner flow into the Jackson River which is part of the James River drainage system.

Summers County, which is the most northern of the three and which separates the other two somewhat after the manner of a dividing wedge, is bounded on the north by Raleigh, Fayette, and Greenbrier Counties, West Virginia; on the east by Greenbrier and Monroe Counties, West Virginia; on the south by Monroe and Mercer Counties, West Virginia, and also by a narrow strip of Giles County, Virginia, which intervenes between these two; and on the west by Mercer and Raleigh Counties, West Virginia. It is almost wholly drained by New River with the aid of Greenbrier and Bluestone both

of which are tributary; but a few square miles along its northwestern border are drained by the headwaters of Meadow River, tributary to Gauley River.

The geographical position of the three counties may be observed on Figures 1 and 2 in this volume, and in greater detail on Maps I-VI, inclusive, enclosed in a separate Atlas accompanying this Report.

TRANSPORTATION.

WATER WAYS.

New River and Tributaries.

Natural water transportation has played only a minor part in the economic development of the three counties. Prior to the advent of the railroads and to some extent in later times **New River** has been utilized for transporting logs and cross-ties to mills or markets, a narrow channel a few miles long having been blasted out in the vicinity of Hinton, but its usefulness in this particular through Summers County, where it crosses the territory under study, has been much limited by the presence of several cataracts ranging from 5 to 25 feet in height, and also by the exceedingly turbulent nature of the stream farther down in Fayette County, making it almost impossible to float a connected raft to the Great Kanawha. The volume of the river through Summers County is sufficiently great to afford slack-water navigation but from Narrows, Virginia, to Meadow Creek, West Virginia, there is a fall of 295 feet in 49.3 miles, making a rate of about 6 feet per mile. From 25 to 30 dams would be required to pool this stretch of the river. From Meadow Creek to the junction of New River with the Great Kanawha River at Gauley Bridge the total fall is 615 feet in 47.8 miles, or at the rate of 12.87 feet per mile. This section would require more than 50 dams, hence the use of New River for steam navigation would be entirely precluded by the enormous cost.

Greenbrier River, tributary to New River at Bellepoint, Summers County, has a fairly normal profile from head to mouth, its rate of fall from Second Creek to its mouth being 6.58 feet per mile. When flush with water it is capable of transporting logs and cross-ties, but is not adapted for boats or large rafts. **Bluestone River** and **East River,** both tributary to New River, the former near True, Summers County, and the latter near Glenlyn, Virginia, are too small and swift to carry anything except loose logs and ties at times of flood.

STEAM RAILROADS.

Cheseapeake and Ohio Railway—Main Line.

The main line of the Chesapeake and Ohio Railway, extending from Fortress Monroe, Virginia, westward across Virginia, West Virginia, and other States, was the first steam road constructed in any of the three counties, its line having been opened for through traffic in 1873. It passes across the extreme northwestern corner of Monroe County at Alderson and thence down Greenbrier and New Rivers across Summers County by way of Hinton and into Fayette and other more western counties; being equipped with double-track except through tunnels and doing an immense business in general freight and passenger service.

In reply to an inquiry concerning the corporate history, construction, trackage in Monroe and Summers Counties, and other items Mr. G. B. Wall, Vice-President, has most kindly supplied the following summary, as explained in his letter, all of which is herein repeated except the Index Map which contains too much detail for successful reproduction on a small scale. The separate items "Extract from Corporate History" and "Corporate History" are in part the same but each contains so many points of interest not found in the other that both are gladly published because of the very great interest that is taken throughout southern West Virginia in the history of this transportation system. The various items, including the letter of transmittal, are as follows:

RICHMOND, VA.,
February 22, 1924.

MR. DAVID B. REGER,
Assistant Geologist, West Virginia Geological Survey,
Morgantown, West Virginia.

Dear Mr. Reger:

"Replying to your letter of the 8th inst., addressed to the Secretary of this Company, New York City, requesting certain information for use in preparation of a geologic and economic report on Mercer, Monroe and Summers Counties, the information requested is given by the attached memoranda, as follows:

(a) Extract from the Corporation History of The Chesapeake and Ohio Railway Company.
(b) The Corporation History of the Chesapeake and Ohio Railway as of date of Valuation, June 30th, 1916.
(c) Memorandum giving dates as to the opening of the Chesapeake and Ohio Railway for operation to Huntington, W. Va.
(d) Memorandum giving mileage of track, both main and siding, in the Counties of Monroe and Summers, W. Va.

"I am also attaching copy of our small Index Map, for your reference.

"Trusting that this will give you the desired information, I am,"

Yours very truly,
(Signed) G. B. WALL,
Vice President.

EXTRACT
from
CORPORATE HISTORY OF THE CHESAPEAKE AND OHIO RAILWAY COMPANY.

FOREWORD.

"This road had its origin in the charter of a company, passed February 18th, 1836, by the Legislature of Virginia, with a capital of $300,000, designed to build a branch road from the Richmond, Fredericksburg and Potomac Railroad through the county of Louisa in Virginia, and was styled **The Louisa Railroad.** It was completed with the capital named in the charter from Hanover Junction to Louisa Courthouse, a distance of thirty-six miles, and for some time was operated by the Richmond, Fredericksburg and Potomac Railroad. Subsequently, it was extended in short sections, at different times as the Company raised the means, under several acts of the legislature, to the eastern base of the Blue Ridge Mountains on the west and to the city of Richmond on the east.

"Upon the second day of February, 1850, an act was passed changing its name to **The Virginia Central Railroad Company.**

"The idea of uniting the waters of the Chesapeake Bay with those of the Ohio River, which had originated with George Washington when he was a surveyor on the banks of the Kanawha River, had at this time taken form in an effort to secure a rail connection. The State of Virginia, on her own account, constructed a road through the Blue Ridge Mountains from their eastern to their western base, authorized an extension to Covington, Virginia, and in the spring of 1861 the **Virginia Central Railroad Company** was operating a line of railway extending from the City of Richmond to Jackson's River ten

miles east of Covington in Alleghany County, Virginia. During the progress of these extensions the policy of the State to carry the road to the Ohio River had been firmly established by the delegation to the Board of Public Works of Virginia of full authority to construct a road from Covington to the Ohio River, on State account, to be known as the **Covington and Ohio Railroad**, under which authority the construction of this part of the work was undertaken by the Commonwealth of Virginia entirely on its own account, and was prosecuted by means of appropriations under several acts of the legislature until interrupted in the spring of 1861 by the beginning of hostilities.

"Upon the dismemberment of Virginia by the formation of the State of West Virginia in 1862, the ownership of that portion of the **Covington and Ohio Railroad**, then partially constructed, lying within the territorial limits of West Virginia, was considered to have devolved upon that State.

"Upon the cessation of hostilities in 1865, the completion of this line of railway being a matter in which the citizens of Virginia and West Virginia were greatly interested, the legislatures of the two States, at their first meeting after the war, passed acts almost identical in terms, providing for the incorporation of the **Covington and Ohio Railroad** and appointing commissioners to arrange for the financing of the enterprise.

"Great difficulty was experienced by the **Covington and Ohio Railroad** commissioners in finding parties able and willing to undertake the heavy expenditures necessary to the construction of that road, and in 1867 other acts were passed by the legislatures of West Virginia and Virginia by which acts additional privileges were conferred upon the **Covington and Ohio Railroad Company** and authority given to the **Virginia Central Railroad** to contract with the Covington and Ohio Railroad Commissioners for the construction of the line, with the provision that in the event such contract be made it should thereafter be known as the **Chesapeake and Ohio Railroad Company**, and should be entitled to all the benefits of the charter of the **Covington and Ohio Railroad Company**, and to all the rights, privileges and interests which by the acts aforesaid were conferred upon the **Chesapeake and Ohio Railroad Company** when organized.

"On the 31st of August, 1868, a contract was made between the commissioners of Virginia and West Virginia and the **Virginia Central Railroad Company**, whereby said company undertook to construct said railroad, and it was contracted, declared and certified by said commissioners that said company should be thereafter known as the **Chesapeake and Ohio Railroad Company**, and be entitled to all the rights, interests, and privileges above referred to.

"By virtue of this contract the **Chesapeake and Ohio Railroad Company** was organized, but being without the means necessary to meet the enormous expenditures required to complete the work, General William C. Wickham, then President of the company, succeeded in interesting Mr. Collis P. Huntington and his associates in the undertaking, and on the sixteenth day of November, 1869, a contract was consummated, and subsequently ratified by the stockholders, which resulted in the successful completion of the enterprise from Covington, Va., to Huntington, W. Va., the connecting rail being laid January 29th, 1873.

"Meantime it acquired the legal title to the Blue Ridge Railroad hereinbefore referred to, by virtue of the provisions of the charter of the **Chesapeake and Ohio Railroad Company**, and upon the twenty-ninth day of June, 1870, it received the conveyance thereof from the State.

"On January 21, 1876, Mr William C. Wickham was appointed receiver of the **Chesapeake and Ohio Railroad Company.** During his receivership a plan for the reorganization of the company was united in by nearly all of the security holders and stockholders. Such proceedings were had from time to time in foreclosure suits as resulted in a sale and conveyance of the property by William C. Wickham, commissioner, appointed by the courts for the purpose, to C. P. Huntington, A. S. Hatch, A. A. Low, Isaac Davenport, Jr., and John Castree, a committee of purchase and reorganization for themselves and others, upon the first day of July, 1878, by virtue of which conveyance, executed under and in pursuance of the decrees of said courts, and of the general statutes then in force in the States of Virginia and West Virginia, said purchasers thereupon became and were duly incorporated under the style of **The Chesapeake and Ohio Railway Company;** and since that time that company has been and is now entitled to all the works, property, estate, rights, franchises, and privileges heretofore owned, used, and enjoyed by its predecessor companies.

"Being now in a position where the company could successfully prosecute its work, the road was extended to Newport News, by virtue of an act of the Legislature of Virginia, approved March 4th, 1880, and to Phoebus, under the terms of an act of the Legislature approved February 21st, 1882; and it was extended westwardly from Huntington to the Big Sandy River, including the bridge across that river under its original charter and supplementary acts of the West Virginia and Kentucky legislatures, connection being thus made with the Elizabethtown, Lexington and Big Sandy Railroad, on the western bank of the Big Sandy River, on the first day of October, 1880.

"Upon the 15th day of June, 1886, said railway was leased to the Newport News and Mississippi Valley Company.

"The rendering of judgments in the Circuit Court of the City of Richmond, Virginia, and the Circuit Court of the County of Kanawha, West Virginia, for the amount of certain advances made by C. P. Huntington, the President of The Chesapeake and Ohio Railway Company, resulted in the appointment, in October, 1887, of General William C. Wickham as again the receiver of the company, under whose management the property was operated until his death on the 23rd day of July, 1888.

"Meantime, at the request of holders of a large amount of securities, the powerful house of Drexel, Morgan & Co. had examined carefully into the affairs of the company, and on the 7th of February, agreed to cooperate in the reorganization of the affairs upon a plan equitable to all interests, and one which would result in placing the company upon a sound financial basis. At their suggestion Messrs. C. H. Costor, R. J. Cross and Anthony J. Thomas undertook to act as a committee to carry the reorganization then proposed into effect, which was done with such success that in September, 1888, it was shown to the Court that the Chesapeake and Ohio Railway Company was prepared to meet all of its obligations as they matured, and to take the possession and management of its property again; whereupon it was ordered that all the property of the company, real and personal, then under the control of the court, should be delivered to Mr. M. E. Ingalls, then President of the company, which was done on the first day of October, 1888, the lease to the Newport News and Mississippi Valley Company having, with the consent of that company, been annulled under the plan of reorganization.

"Under the management of Mr. Ingalls, who remained as President of the road until the early part of 1900, and his successor, Mr.

George W. Stevens, now President of the company, The Chesapeake and Ohio has progressed steadily. In 1889 it acquired the Richmond and Alleghany Railroad, extending from Richmond along the James River, or what formerly was the old James River and Kanawha Canal, to Clifton Forge, connecting at both Richmond and Clifton Forge with the original line, the length of this line with its branches being 251.04 miles. Other lines have been acquired, either by original construction, purchase or merger, as will be seen from the data set forth in the accompanying sheets, until now the railroad of this company consists of 1832.31 miles of line; 686.69 miles of which are in the State of Virginia, 709.25 miles in the State of West Virginia, and 436.37 miles in the State of Kentucky, all of which is operated by its own organization, with the exception of 5.0 miles of line extending from Esmont, Va., to Alberene, Va., which is leased to the Nelson and Albemarle Railway Company for 10 years from November 1, 1915.

"Between Newport News, Norfolk and Portsmouth, Virginia, and other points on the Seaboard, The Chesapeake and Ohio operates passenger and freight floating equipment, the distance from Newport News being 14 miles and from Norfolk to Portsmouth 1 mile."

CORPORATE HISTORY OF THE CHESAPEAKE AND OHIO RAILWAY COMPANY.

As of the Date of Valuation, June 30, 1916.

NAME—The Louisa Railroad Company

INCORPORATION

Incorporated under the Special Act of the General Assembly of the State of Virginia passed February 18, 1836 (Acts of Virginia 1835-6, chapter 126, page 168).

Extensions authorized by Special Acts of the General Assembly of the State of Virginia passed March 27, 1838 (Acts of Virginia 1838, C. 156, Page 110); March 8, 1847 (Acts of Virginia 1847-8, Chapter 112); March 27, 1848 (Acts of Virginia 1847-8, Chapter 154, Page 188); March 5, 1849 (Acts of Virginia 1848-9, Chapter 147, Page 99); and January 30, 1850 (Acts of Virginia 1849-50, Chapter 73, Page 51).

ORGANIZATION

June 13, 1836.

By-Laws adopted. Officers and Directors elected.

CONSTRUCTION

The construction commenced in 1836, completed and opened for operation as follows:

	Miles
Doswell (Hanover Junction), Virginia, to Fredericks Hall, Virginia, December 20, 1837	22.80
Fredericks Hall, Virginia, to Louisa, Virginia, December 1, 1838	11.90
Louisa, Virginia, to Gordonville, Virginia, April 10, 1840	13.90
Gordonville, Virginia, to Cobham, Virginia, August 14, 1848	7.00
Cobham, Virginia, to Rogers Mill, Virginia, December 19, 1848	7.00
Rogers Mill, Virginia, to Shadwell, Virginia, May 1, 1849	2.00

TERMINI AND DESCRIPTION

1st Track Mileage.

Doswell, Virginia, to Shadwell, Virginia..... 64.60 Miles

OPERATION

From December 20, 1837, to June 30, 1847, by the Richmond, Fredericksburg and Potomac Railroad Company under contract dated July 10, 1837, and renewed each year until 1844 and contract dated May 30, 1844, effective 3½ years from January 1, 1844.

From July 1, 1847, to February 1, 1859, by own organization.

NAME CHANGED

Under a Special Act of the General Assembly of the State of Virginia passed February 2, 1850 (Acts of Virginia 1849-50, Chapter 74, Page 52), the name of The Louisa Railroad Company was changed to Virginia Central Railroad Company.

NAME—Virginia Central Railroad Company

INCORPORATION

Name changed from The Louisa Railroad Company to the Virginia Central Railroad Company by a Special Act of the General Assembly of the State of Virginia passed February 2, 1850 (Acts of Virginia 1849, Chapter 74, Page 52). See narrative of the Louisa Railroad Company, page 5.

ORGANIZATION

February 2, 1850.

CONSTRUCTION

After February 2, 1850, when the name of The Louisa Railroad Company was changed to The Virginia Central Railroad Company, the construction was continued by The Virginia Central Railroad Company, which Company completed and owned for operation the following road:

	Miles
Shadwell, Virginia, to Charlottesville, Virginia, Spring of 1850	5.00
Doswell, Virginia, to Richmond, Virginia, January 1, 1851	26.30
Charlottesville, Virginia, to Ivy, Virginia, December, 1851	7.50
Ivy, Virginia, to Mechums River (Blairs Park), Virginia, December 6, 1852	2.79
Waynesboro, Virginia, to Staunton, Virginia, Summer of 1854	12.40
Staunton, Virginia, to Goshen, Virginia, Year 1855	32.00
Goshen, Virginia, to Millboro, Virginia, July, 1856	7.00
Millboro, Virginia, to Jackson River, Virginia, July 10, 1857	17.20
Jackson River, Virginia, to Covington, Virginia	12.60

The grading and masonry between Jackson River, Virginia, and Covington, Virginia, was completed in 1861, but rail was not laid on account of the Civil War. The road was finally completed and opened for operation July 31, 1867.

TERMINI AND DESCRIPTION

1st Track Mileage.

Richmond, Virginia, to Mechums River, Virginia	106.19 Miles
Waynesboro, Virginia, to Covington, Virginia	81.20 Miles
Total	187.39 Miles

OPERATION

From February 2, 1850, to August 31, 1868, by own organization.

NAME—Chesapeake and Ohio Railway Company

INCORPORATION

By authority of a Special Act of the legislature of the State of West Virginia passed February 26, 1867 (Acts of West Virginia 1867, Chapter 93, Page 102), and a Special Act of the legislature of the State of Virginia passed March 1, 1867 (Acts of Virginia 1867, Chapter 280), The Virginia Central Railroad Company entered into a contract dated August 31, 1868. with the Commissioners of The Covington and Ohio Railroad Company whereby the Virginia Central Railroad Company agreed to construct the road from Covington, Virginia, to the Ohio River. In pursuance of these Acts the name of the Virginia Central Railroad Company was changed to the Chesapeake and Ohio Railroad Company, which company succeeded to all the rights, franchises, property, etc., of the Covington and Ohio Railroad Company.

ACQUISITION

By a contract dated August 31, 1868, and in pursuance of the Act of Virginia passed March 1, 1867, and Act of West Virginia passed February 26, 1867, the property, rights, franchises, etc., of The Covington and Ohio Railroad Company were transferred to the Chesapeake and Ohio Railroad Company.

By deed dated June 29, 1870, effective April 1, 1870, the right, title and interests of the State of Virginia in the Blue Ridge Railroad Company was conveyed to the Chesapeake and Ohio Railroad Company (16.81 miles of first track from Mechums River, Virginia, to Waynesboro, Virginia).

ORGANIZATION

August 31, 1868. Same as Virginia.

CONSTRUCTION

Covington, Virginia, to White Sulphur, West Virginia, 23.00 miles, completed and opened for operation July, 1, 1869.

White Sulphur, West Virginia, to Huntington, West Virginia, 190.03 miles, completed and opened for operation March, 1873. From Carrington Street in Richmond, Virginia, through Church Hill tunnel (350 feet) to a point East of the City of Richomnd, completed 1874, 1.67 miles.

TERMINI AND DESCRIPTION

1st Track Mileage.

From a point east of the City of Richmond, Virginia, to Virginia-West Virginia State line..	222.00 Miles
From Virginia-West Virginia State line to Huntington, West Virginia.....	196.90 Miles
Total	418.90 Miles

Track in the Counties of Monroe and Summers, in West Virginia:

	1st Track	2nd Track	Sidings
Monroe County.....	2.90	2.90	1.99
Summers County.....	33.33	31.71	21.81

MEMORANDUM.

A. H. Perry, General Superintendent, in his report of October 1, 1872, stated:

Road opened for operation from Huntington to Charleston, December 4, 1871.
To Coalburg, March 4, 1872.
To Kanawha Falls, June 17, 1872.

Mr. Whitcomb, Chief Engineer, in his report of October 1, 1873, stated:
Rail connected, January 29, 1873.
Road opened for business in March, 1873.

Sewell Valley Railroad.—The Sewell Valley Railroad which is tributary to the Chesapeake and Ohio Railway at Meadow Creek, Summers County, extends northeastward 40 miles to the valley of Meadow River. Historical details and certain other desired data concerning this road are not available since no reply could be obtained from officials of the company, but the following description by Ray V. Hennen is published on pages 14-15 of the Fayette County Report of the Survey:

"The Sewell Valley Railroad extends from Meadow Creek Station on the main line of the Chesapeake and Ohio Railway northeastward along Meadow Creek and down Sewell Creek to Rainelle on Meadow River, and thence down the latter stream to Wilderness (Nallen P. O.), ½ mile north of the common corner of Fayette, Greenbrier, and Nicholas Counties. It has an immense traffic in lumber from the large band mills at Rainelle, Honeydew and Nallen. It also carries the commercial coal production of a mine in what appears to be the No. 6 Pocahontas bed, 1 mile northward from Rainelle. That portion from Meadow Creek to Rainelle was completed several years ago and that below the latter point to Wilderness, during the early part of 1916."

Norfolk and Western Railway—Main Line.

The main line of the Norfolk and Western Railway, extending from Norfolk, Virginia, westward across Virginia and West Virginia and thence to Cincinnati and Columbus, Ohio, enters Mercer County near Glenlyn, Virginia, passes up East River to the summit at Bluefield, and thence down Bluestone River, partly in West Virginia and partly in Virginia to Coopers, West Virginia, where it leaves the river and ascends Mill Creek, and thence descends Elkhorn Creek into McDowell County. Passing down Elkhorn Creek, Tug Fork of Big Sandy River and Big Sandy River itself it crosses into Ohio at Kenova. In Mercer County its position is near the southern border but there are several branches extending

northward into the coal region of the western part, as will be later enumerated. The main line, which was completed across Mercer County in 1883, is now almost entirely double-tracked through the county, and from Vivian, McDowell County, eastward to Bluefield it is operated by electric power. The road affords general freight and passenger service, the greatest single freight item being coal.

In reply to an inquiry concerning the corporate history, construction, trackage in Mercer and Monroe Counties, and other points of interest, the following letter from Mr. I. W. Booth, Secretary, contains valuable historical and industrial data:

PHILADELPHIA, PA.,
March 18th, 1924.

MR. DAVID B. REGER, Assistant Geologist,
West Virginia Geological Survey,
Office of the Survey,
Morgantown, W. Va.

Dear Sir:

"Your letter of February 7th was duly received, and in accordance therewith I give you below information desired in the order in which your questions were sent out:

"1 and 2. In preparing brief outline of the corporate history of the Norfolk and Western Railway Company, I shall begin with the incorporation of the first company which became a portion of the line of the present company as follows:

"City Point Railroad incorporated Virginia January 26th, 1836, to construct railroad from Petersburg, Virginia, to James River, at or near City Point, Virginia. Main line 9 miles. Constructed between April, 1837, and May, 1839. Purchased by City of Petersburg, Virginia, July 17th, 1847, and reorganized as Appomattox Railroad Company under Virginia Act of March 19th, 1847.

"Southside Railroad Company incorporated Virginia, March 5th, 1846, to construct railroad from Petersburg, Virginia, westward, subsequently to Lynchburg, Virginia. Main line 123 miles. Commenced December 29th, 1849, completed October 1st, 1854. Southside Railroad Company purchased from City of Petersburg, Virginia, The Appomattox Railroad Company under Virginia authority of February 2nd, 1854.

"Lynchburg and Tennessee Railroad Company incorporated Virginia, March 24th, 1848, and name subsequently changed under Virginia Act of March 6th, 1849, to Virginia and Tennessee Railroad Company, to construct railroad from Lynchburg, Virginia, to Bristol, on the Virginia-Tennessee Line. Main line 204.24 miles. Construction commenced June 17th, 1849, completed October 1st, 1856.

"Norfolk and Petersburg Railroad Company incorporated Virginia, March 17th, 1851, to construct railroad from Norfolk, Virginia, to connect with Southside Railroad Company at Petersburg, Virginia. Main line 80 miles. Commenced in May, 1853, completed September 1st, 1858.

"Virginia and Kentucky Railroad Company incorporated Virginia, March 3rd, 1853, to construct railroad from Kentucky line at or near Cumberland Gap, Virginia, to Abingdon, Virginia. While some work

was done on this line, it was never completed. It is mentioned only because it is referred to in the history of the company.

"Atlantic, Mississippi and Ohio Railroad Company, incorporated Virginia, June 17th, 1870, consolidation of Norfolk and Petersburg Railroad Company, Southside Railroad Company, Virginia and Tennessee Railroad Company and Virginia and Kentucky Railroad Company. The Atlantic, Mississippi and Ohio Railroad Company thus acquired a continuous line of railroad completed and in operation from Norfolk, Virginia, to Bristol, on the state line of Virginia-Tennessee. The main line mileage was 408.30, with branch mileage of 18.42, being City Point Branch 9 miles; Saltville Branch 9.42 miles, making a total mileage of 426.72. This company did no construction work. This company went into the hands of receivers April 1st, 1871, and was so operated until May 22nd, 1881. It was, however, sold under foreclosure proceedings February 10th, 1881.

"Norfolk and Western Railroad Company was created and organized in Virginia, May 3rd, 1881, by the purchase of the Atlantic, Mississippi and Ohio Railroad Company, which company was reorganized on that date as Norfolk and Western Railroad Company.

"Norfolk Drawbridge Company incorporated Virginia, January 5th, 1803, by deed dated July 7th, 1881, conveyed its property, including bridge over the Eastern Branch of Elizabeth River, to the Norfolk and Western Railroad Company.

"New River Railroad, Mining and Manufacturing Company incorporated West Virginia, September 14th, 1874, to construct railroad from point on Chesapeake and Ohio Railroad near mouth of Greenbrier River, Summers County, along the New River Valley through Summers, Monroe and Mercer Counties to Virginia line.

"Blue Stone Railroad Company incorporated West Virginia, February 25th, 1881, to construct railroad from a point on New River, near mouth of Blue Stone River to Summers County, West Virginia, to connect with New River Railroad, thence up Blue Stone River to Gladesville, in Mercer County.

"The railroads of the New River Railroad, Mining and Manufacturing Company and Blue Stone Railroad Company were never constructed, although New River Railroad, Mining and Manufacturing Company and its successor, the New River Railroad Company of West Virginia, did acquire certain rights of way in West Virginia.

"New River Railroad Company of West Virginia formed under laws of West Virginia, by consolidation of New River Railroad, Mining and Manufacturing Company and Blue Stone Railroad Company, December 22nd, 1881, to construct lines as above and extend line to Narrows, Virginia. Line of this company was located during 1880 and 1881. Some work was done by this company, but no railroad was completed before company was consolidated with Norfolk and Western Railroad Company.

"East River Railroad Company was incorporated in West Virginia, March 25th, 1881, to construct a railroad from point on East River, Virginia State line, Mercer County, West Virginia, along East River to Tazewell County line, Virginia, crossing State line into Virginia, where necessary. This line was located in 1881, and some grading done, but no railroad completed prior to consolidation with Norfolk and Western Railroad Company.

"New River Railroad Company (of Virginia), was chartered in Virginia, March 7th, 1872, as New River Railroad, Mining and Manufacturing Company, but subsequently under supplemental charter of April 4th, 1877, changed its name to New River Railroad Company.

This company had privilege to construct railroad from some point on North Carolina State line down New River, via New River Depot on Atlantic, Mississippi and Ohio Railroad to West Virginia and Virginia State line, as well as branch roads necessary to bring out coal, ore, minerals, etc., from counties adjacent thereto in State of Virginia. First preliminary survey through Pulaski and Giles Counties, thence down New River in West Virginia, was made by Virginia and Tennessee Railroad Company in 1851 as probable branch. This line was located during 1879-1880 and some grading was done but no railroad was completed until after the company consolidated with Norfolk and Western Railroad Company.

"On May 9th, 1882, the New River Railroad Company (of Virginia), the New River Railroad Company of West Virginia, and the East River Railroad Company (of West Virginia) were consolidated with Norfolk and Western Railroad Company, which consolidated lines were designated by the Norfolk and Western Railroad Company as New River Division of the Norfolk and Western Railroad Company. Construction on these lines was begun in 1881, the route being from Main Line of Norfolk and Western Railroad at New River Depot to coal deposits at Pocahontas, which line was opened May 21st, 1883, the mileage being 74.25. A part of Cripple Creek Extension of New River Division was located during 1882, and construction work from Pulaski, Virginia, to Fosters Falls, Virginia, begun December, 1883. 25.5 miles of this line were put into operation October 6th, 1886, and during 1887 and 1888, and extended to Ivanhoe, Virginia, with a total length of 30.4 miles of main line..

"West Virginia and Ironton Railroad Company incorporated West Virginia, March 7th, 1888, to construct railroad at a point in McDowell County, West Virginia, near confluence of Burke Creek and Elkhorn Fork of Big Sandy River, to Ohio River, in Wayne County, West Virginia. In July, 1889, this company extended its line beyond Ohio River to Ironton, Lawrence County, Ohio; also beyond its southern terminus in McDowell County, West Virginia, at or near confluence of Burke Creek and Elkhorn Fork of Big Sandy River to a point near track of Elkhorn Extension of Norfolk and Western Railroad Company, near operations of Powhatan Coal and Coke Company, McDowell County, West Virginia. October 17th, 1889, this company was leased to the Norfolk and Western Railroad Company for 101 years.

"Norfolk and Western Railroad Company was organized September 24th, 1896, under Act of Assembly of Virginia, approved January 15th, 1896, to operate the railroads and properties of the Norfolk and Western Railroad Company sold for foreclosure September 15th, 1896.

"In further response to your desire for brief outline of corporate history, I enclose a chart which shows the corporate name, place and date of incorporation and disposition of the property through the entire corporate existence, beginning with City Point Railroad Company No. 1 down to and including the Norfolk and Western Railway Company and its subsidiary lines organized subsequent to the organization of the Norfolk and Western Railway Company.

"In the above mentioned chart you will note under the heading 'Railway Companies Controlled by Norfolk and Western Railway Company Through Stock Ownership but Independently Operated', reference to the Virginia-Carolina Railway Company and the New River, Holston and Western Railroad Company. The properties and franchises of these two companies were conveyed to the Norfolk and Western Railway Company by deeds dated as follows:

The New River, Holston and Western Railroad Company, May 13th, 1919.

The Virginia-Carolina Railway Company, August 27th, 1919.

"The Tug River and Kentucky Railroad Company and the Williamson and Pond Creek Railroad Company, also included in said table, were leased to the Norfolk and Western Railway Company for a period of 99 years, and are now operated by the Norfolk and Western Railway Company under said leases.

"In response to your third inquiry relative to number of Main line double trackage, single trackage and sidings in Mercer County, West Virginia, I give you this information below:

Double Track—Main Line	31.40
Single Track—Main Line	.70
Sidings Track—Main Line	59.61

"In response to inquiry number 4, relative to names of branch lines in Mercer County, with dates of beginning and completion, I give below such information as I have available:

	Completed	Branch Mileage	Siding Mileage
Pocahontas Branch (Portion only in Mercer County)	1883	.75	.26
Bluestone Branch	1888	5.96	3.20
Simmons Creek Branch	1888	3.01	2.44
Flipping Creek Branch	1888	4.02	1.41
Mill Creek Branch	1889	.48	.85
Crane Creek Branch	1902	7.67	5.93
Widemouth Branch	1904	23.39	10.10

"Your question number five. The Potts Valley Branch was acquired by Norfolk and Western Railway Company under the name of Big Stony Railway Company, which operated from Big Stony Junction to Interior, Virginia, a distance of 10.51 miles. Extended the same to West Virginia State Line at M. P. 16.65; thence through Monroe County, West Virginia, under charter of Interior and West Virginia Railroad to the Virginia State line at M. P. 34.18, a distance of 17.53 miles, and thence into Craig County, Virginia, just beyond Paint Bank Station under charter of the Virginia and Potts Creek Railroad. Moved part of Potts Valley Branch to M. P. 38.33—end of, and length of branch.

"Grading on extension beyond Interior began in May, 1907. Work shut down in December, 1907; resumed in September, 1908; finished in May, 1909.

"Track laying crossed West Virginia State line on December 22nd, 1908, M. P. 16.65, and crossed State line at M. P. 34.18 August 19th, 1909—stopped at end of branch September 14th, 1909.

"Opened to Waiteville, August, 1909.

"Opened to Paint Bank, October, 1909.

"Length of sidings in Monroe County, West Virginia, 1.18 miles.

"In response to your inquiry number six, the system of electrification for that part of the Norfolk and Western Main Line from Bluefield west and including what is known as the Elkhorn Grade between Bluefield and Vivian was inaugurated in 1915.

"Power is generated at the Power House located at Bluestone, West Virginia.

"Capacity of Power House—36,000 K. W.

"Capacity of Units, each—4—9,000 K. W.

"Kind of Units—Steam turbine.

"Revolutions per minute of Generators—1,500.

"We trust the above will give you the information desired, and I regret the delay in furnishing this information, which was entirely unavoidable because of pressure of other matters in my office, in connection with the closing of our records for the year 1923, and preparation of Annual Report for our stockholders.'

Yours truly,
(Signed) I. W. BOOTH,
Secretary.

Norfolk and Western Railway—Potts Valley Branch.—As mentioned above by Mr. Booth, the Potts Valley Branch of the Norfolk and Western Railway serves a portion of southern Monroe County. This road leaves the main line at Ripplemead, Virginia, passes down the west side of New River with the main track for about 1½ miles, crosses to the east side, and one-half mile farther down turns eastward up Stony Creek. At the head of this creek it goes into Monroe County through a high pass in the cross ridge between Peters and Potts Mountains, and passing down into the valley of Potts Creek by a tortuous route reaches the Virginia line again 2.4 miles east of Laurel Branch and finally terminates about one-half mile east of Paint Bank, Virginia. Built primarily to remove timber and iron ore from Potts Valley this branch does a general freight and passenger business.

Norfolk and Western Railway—Bluestone River Branches.—The various coal-carrying branches in western Mercer County, which deliver their tonnage to the main line of the Norfolk and Western at Coopers, as well as the Pocahontas Branch which is tributary at Bluestone, have already been summarized by Mr. Booth in his letter published above. The positions of all these branches are indicated on Maps I and II, so that no further detailed description is needed.

Virginian Railway.

The Virginian Railway, extending from Sewalls Point, Virginia, westward across Virginia and through West Virginia to Deepwater on the Great Kanawha River in Fayette County, enters Mercer County near Glenlyn, Virginia, passes westward along the bluffs north of East River to Ingleside, thence northwestward through Princeton to the watershed

of Bluestone River, thence southwestward with the same to Rock, thence northwestward up Widemouth Creek to Clarks Gap Tunnel where it enters Wyoming County. Crossing Guyandot River at Mullens, Wyoming County, it then turns northward through Raleigh and Fayette Counties, finally reaching Deepwater. Its route through West Virginia is such that heavy construction was required, there being numerous huge cuts, immense viaducts and frequent tunnels. This road which was completed through Mercer County in 1909, does a general freight and passenger business, its principal tonnage being coal. It is now operated by steam locomotives but, as is later shown, the section between Mullens, West Virginia, and Roanoke, Virginia, will eventually be electrified.

The following letter from Mr. James Clarke, Secretary, in response to an inquiry concerning certain items, gives valuable historical and statistical data concerning this comparatively young railroad:

NEW YORK,
April 9, 1924.

DAVID B. REGER, Esq., Assistant Geologist,
West Virginia Geological Survey,
Box 816,
Morgantown, W. Va.

Dear Sir:

"Press of work and delays incident to obtaining the necessary information both here and at Norfolk has heretofore prevented my replying to your letter of February 8, 1924, until to-day.

"The Virginian Railway Company is a corporation of the Commonwealth of Virginia, and was incorporated under the name of **Tidewater Railway Company,** under a general statute of the Commonwealth of Virginia, on the 20th day of February, 1904, and organized on the same date. Amendments have been made to its charter on the dates following.

"February 26, 1904; September 6, 1904; November 25, 1904: December 29, 1904; March 8, 1907; November 6, 1908.

'By the amendment of March 8, 1907, the corporate name was changed to **The Virginian Railway Company.**

"The main line of the railroad extends in Virginia from the center of Boush Creek, near Sewalls Point, in Norfolk County, Virginia, its connection with the Virginian Terminal Railway, westerly to the Virginia-West Virginia State Line near Glenlyn, Virginia, a distance of 329.49 miles, with a main line wye connecting with the Norfolk Southern Railroad at Tidewater Junction, .17 of a mile, and in West Virginia from the Virginia-West Virginia State line near Glenlyn to Deepwater, West Virginia, on the Kanawha River and Chesapeake and Ohio Railway, 111.33 miles. The main line in Virginia was constructed by The Virginian (Tidewater) Railway Company during the years 1905 to 1908, inclusive. The main line in West Virginia was partly

constructed by The Deepwater Railway Company and was completed by The Virginian Railway Company after the acquisition thereof, as shown below in respect of The Deepwater Railway Company.

"The Deepwater Railway Company was a corporation of West Virginia, incorporated under the general laws of said State on January 25, 1898, and organized on March 4, 1898. It was dissolved in February, 1922.

"The property of The Deepwater Railway Company was conveyed to The Virginian Railway Company by deed dated April 22, 1907. The property so conveyed consisted of a right of way extending from the Virginia-West Virginia State Line near Glenlyn, Virginia, to Deepwater, West Virginia, on the Kanawha River and Chesapeake and Ohio Railway, a main line distance of 111.33 miles. The 4 miles extending east or south from Deepwater was built during the year 1898, the remainder during the years 1903 to 1908, inclusive. At the time of the conveyance, the road was in operation between Deepwater and Mullens, a distance of 59 miles, some additional track had been laid east of Mullens, and the remainder of the road to the State Line was under construction. A revision of the main line at Cow Hollow Creek, 3 miles west of Bishop and .56 of a mile in length, was constucted in 1911. A revision of the main line west of Harper, and 2 miles in length, was constructed during the years 1911-12. Sundry branches since built connecting with the main line above referred to have been built by The Virginian Railway since the conveyance to it.

"The 4 miles of track built in 1898, as above stated, was operated by the Chesapeake and Ohio Railway for several years. The Deepwater Railway Company began operating the same in 1903, and continued to operate the track thereafter until April 22, 1907.

"The number of miles of double track railroad owned by The Virginian Railway Company in Mercer County, W. Va., is 1.17 miles. The number of miles of single track main line is 36.32 and there are 39.84 miles of side tracks.

"The construction of the Virginian Railway in Mercer County was begun in June, 1904, and the line officially put in operation June 30th, 1909.

"The Virginian Railway has no branch lines in Mercer County.

"The lumber railway owned by the Bluestone Land and Lumber Company which connected with the Virginian Railway at Gardner Junction is not now in existence. The connection for this line was made in 1908 and removed March, 1923.

"In regard to the electrification, this company entered into a contract dated April 18, 1923, with the Westinghouse Electric and Manufacturing Company covering the electrification of 134 miles of the line between Mullens, West Virginia, and Roanoke, Virginia. Power will be generated at our new power plant now being constructed at Narrows, Va., coal being used for that purpose.

"Trusting that the foregoing will give you the information you desire, and hoping that you have not been inconvenienced by the delay, I am,"

Yours very truly,
(Signed) JAS. CLARKE,
Secretary.

INTERURBAN RAILROADS.

Princeton Power Company.

Rail transportation between Princeton and Bluefield, Mercer County, and Graham, Virginia, is afforded by the trolley lines of the Princeton Power Company, of Princeton, West Virginia. This company operates not only the interurban lines connecting the three municipalities but also the local lines within the bounds of each corporation. In reply to an inquiry the following letter from Mr. S. J. Evans, General Manager, gives the corporate history and indicates the service provided by this company:

PRINCETON, W. VA.,
February 21, 1924.

West Virginia Geological Survey,
Morgantown, West Virginia.
Attention Mr. David B. Reger.

Dear Sir:

"Answering your letter of the 7th inst., I have to advise as follows:

"The Princeton Power Company was incorporated under the laws of this state August 15, 1907, with capitalization of $100,000.00. This charter was amended January 31, 1923, increasing the capitalization to $300,000.00.

"The Electric Light Steam Plant was put in operation June, 1908.

"The Street Railway from the Virginian Station along Mercer and Main Streets to the Court House, a distance of 6,000 feet, was built and put in operation December, 1909.

"The Interurban Line between Princeton and Bluefield. Grading was begun in 1914 and completed and placed in operation July 1, 1916. In December, 1920, we purchased the entire railway system in the City of Bluefield and Graham, Va. In 1921 an extension of 1¼ miles was built to West Graham. This was placed in operation December 24th, same year.

"The mileage of the entire system now represents a total of 22.35 miles.

"In September, 1916, our Steam Plant was abandoned and current since that time is purchased from the Appalachian Power Company, of Bluefield, W. Va.

"Any further information we can give you we will be pleased to do so."

Very truly yours,
(Signed) S. J. EVANS,
General Manager.

HIGHWAYS.

State Roads.

Following a revision of the road laws by the Legislature of 1921 the State Road Commission has indicated on its official map and otherwise designated certain existing or projected highways as **State Routes,** the construction and maintenance of which has been undertaken by the State through the agency of the Road Commission, together with such assistance as may be had from the United States Government. When these projects are finally completed the routes become **State Roads.**

From the 1923 edition of the State Route Map of the Commission, in conjunction with the more detailed Government topographic maps, the writer has compiled the following description of the State routes in Mercer, Monroe, and Summers Counties, their terminals in other counties or at State lines being indicated:

State Route No. 4.—State Route No. 4 begins at the Virginia State Line just east of Graham, Virginia, proceeds northeastward in Mercer County through Bluefield, Stony Gap and Carr School (Glenwood) to Princeton; thence northwestward to Kegley; thence northward through Spanishburg, Camp Creek and Flattop to the Mercer-Raleigh County line, thence generally northward through Raleigh, Fayette, Nicholas, Braxton, Lewis, Harrison, Marion, and Monongalia Counties to the Pennsylvania State line near Point Marion. Of the portion in Mercer County paving has been completed from the Virginia line to Princeton, grading is completed from Princeton to Kegley, and grading is under construction from Kegley to Flattop.

State Route No. 8.—State Route No. 8 begins on State Route No. 4 about one mile northeast of Graham, Virginia, proceeds northwestward through Brush Fork and Bramwell, Mercer County, to the McDowell County line 1½ miles east of Maybeury; thence westward and northwestward through McDowell, Mingo (including a small section in Logan), Wayne, and Cabell Counties to the Ohio State line at Hunt-

ington. Of the portion in Mercer County paving is completed from Route No. 4 to the Beaver Pond-Rock District line near Bramwell and grading is completed from that point to the McDowell County line.

State Route No. 20.—State Route No. 20 starts at Princeton, proceeds northeastward in Mercer and Summers Counties through Athens, Pride, Lerona, Pipestem, True, Hinton, Barksdale, Brooks, Sandstone, New Richmond, Green Sulphur Springs, and Elton to the Fayette County line two miles east of Meadowbridge; thence northward through Fayette and Greenbrier Counties to an intersection with State Route No. 3 at Rainelle, Greenbrier County. Of the portion in Mercer and Summers Counties paving is completed from Princeton to Athens; grading is completed from Athens to the Mercer-Summers County line; the road is unimproved from this point to Pipestem; grading is done from Pipestem to Hinton; grading is under construction from Hinton to Brooks, and the route is unimproved from Brooks to the Fayette County line, there being a section along New River between Brooks and Sandstone where no road of any description exists.

State Route No. 21.—State Route No. 21 starts from State Route No. 24 at Ronceverte, Greenbrier County, proceeds westward through this county to the Summers County line one mile west of Alderson; thence southwestward and westward in Summers County through Clayton, and on the north side of Greenbrier River opposite Pence Springs and Lowell, and through Talcott, Hilldale, Bellepoint, Hinton, and Jumping Branch to the Raleigh County line three miles west of Jumping Branch; thence northwestward in Raleigh County to an intersection with State Route No. 4 at Shady Spring. Of the portion in Summers County grading is under construction from the Greenbrier County line to Pence Springs; grading is finished from Pence Springs to the mouth of Big Creek, 2½ miles east of Bellepoint; paving is completed from Big Creek to Hinton; grading is completed from Hinton to Jumping Branch and grading is under construction from Jumping Branch to the Raleigh County line.

State Route No. 24.—State Route No. 24 starts at Princeton, proceeds eastward in Mercer County through Goodwyn Chapel and Kellysville to the Virginia State line near Glenlyn, Virginia, thence the present route is by unimproved road to Lurich, Virginia, and thence up the west side of New River to Narrows, Virginia, and down the east side of the same stream to Rich Creek opposite Lurich, and thence northeastward to Peterstown, West Virginia; thence northeastward in Monroe County through Lindside, Rock Camp, Raines Corner, Salt Sulphur Springs, Union, Pickaway, and Monitor to the Greenbrier County line two miles east of Patton; thence northeastward or northward through Greenbrier, Pocahontas, and Randolph Counties to an intersection with State Route No. 56 at Huttonsville, Randolph County. Of the portions in Mercer and Monroe Counties grading is completed from Princeton to the Virginia State line near Glenlyn, the road is unimproved from Peterstown to Rock Camp, grading is completed from Rock Camp to Raines Corner; grading is under construction from Raines Corner to Union; paving is completed from Union to Monitor, and grading is completed from Monitor to the Greenbrier County line.

State Route No. 67.—State Route No. 67 starts on State Route No. 4 at Carr School (Glenwood) southwest of Princeton, proceeds westward and northwestward in Mercer County through Rock and Matoaka to the Wyoming County line; thence generally northwestward through Wyoming and Logan Counties to an intersection with State Route No. 2 at Stollings just east of Logan. Of the portion in Mercer County paving has been completed from Carr School (Glenwood) to Rock; grading is done from Rock to Matoaka, and the remainder is unimproved.

State Route No. 71.—State Route No. 71 starts at Alderson on State Route No. 21, proceeds southward in Monroe County to Wolf Creek; eastward to Sinks Grove and southeastward to an intersection with State Route No. 24 at Pickaway. Of this route none is indicated as improved although some grading has been done along Wolf Creek.

County Roads.

All roads in the three counties not assumed by the State Road Commission are built and maintained by local taxation under the supervision of the County Commissioners of the different counties. All three counties in the territory of this Report, with the exception of a small section in southern Monroe, are fairly well covered with a network of dirt roads, few of which have been well graded or surfaced and only a fraction of which has been paved. Perhaps one-half of these roads may be traversed by automobile in summer, the remainder being too rough or too steep for this method of travel. According to the Report of the State Road Commission for 1914 Mercer County has 375 miles of roads, Monroe County has 700 miles, and Summers County has 485, the figures being inclusive of the roads now operated by the State Road Commission but there being no available record of roads built since 1914.

GENERAL DESCRIPTION, MERCER COUNTY.

MISCELLANEOUS ITEMS.

Formation.—Mercer County was formed from parts of Giles and Tazewell Counties, Virginia, March 17, 1837, by Act of the Virginia General Assembly, and named in honor of General Hugh Mercer who was killed in battle at the present site of the city of Princeton. The portion of this act describing the boundaries is quoted by David E. Johnston[2] as follows:

"Beginning at the mouth of East River, in Giles County, and following the meanders thereof up to Toney's mill dam; thence along the top of said mountain, East River Mountain, (the line from Toney's mill dam to the top of the mountain was evidently omitted in the act); to a point opposite the upper end of the old plantation of Jesse Belcher, deceased, thence a straight line to Peery's mill dam near the mouth of Alp's (Abb's) Valley, thence to a point well known by the name of the Peeled (Pealed) Chestnuts, thence to the top of the Flat Top Mountain, thence along said mountain to New River, thence up and along the various meanderings of the same to the beginning, shall form one distinct and new county, and be called and known by the

[2]David E. Johnston, History of the Middle New River Settlements and Contiguous Territory, p. 170; 1906.

name of Mercer County, in memory of General Hugh Mercer, who fell at Princeton."

Subsequent to the above act a change was made in the line from the top of the East River to Peery's Mill dam by Act of the Virginia Assembly; also a small amount of territory on the west side of New River north of the mouth of East River was returned to Giles County in 1841 by Act of Assembly; and in 1871 the creation of Summers County removed from Mercer County the territory on the west side of New River now comprising Jumping Branch and Pipestem Districts of the former county. The present boundaries are accurately shown on Map I.

Area.—The present area of Mercer County, as determined with planimeter by the writer from the topographic sheets of the United States Geological Survey, including the two districts previously described by C. E. Krebs in the Raleigh County Report of the Survey, is as follows:

Mercer County Areas.

Districts	Square Miles
Beaver Pond	82.42
East River	84.94
Plymouth	68.39
Rock (Described in Raleigh County Report)	135.46
Jumping Branch (Described in Raleigh County Report)	52.70
Total	423.91

Relief.—The surface of Mercer County varies in elevation from 1450 feet on New River at the mouth of Roundbottom Creek at the extreme northeastern corner of the county to 4020 feet at Buckhorn Knob of East River Mountain at the head of Pigeon Creek 3 miles southwest of Oakvale, making a total difference of 2570 feet.

Climate.—Compared to the western and northern portions of West Virginia the climate of Mercer County may be classed almost entirely as of mountain type, since the major portion of its topography is an elevated plateau ranging from 2000 to 2500 feet above sea-level with numerous higher hills

and mountains, while only a small amount of the land surface has been cut down below the 2000 foot level by the narrow valleys of some of the major streams. A summer season perceptibly shorter than that of the lowlands of the Ohio River Valley is the result, with a somewhat more severe winter. The slight curtailment of the growing season, however, is perhaps fully compensated for by the more bracing and healthful atmosphere. In all parts of the county good health is the rule, climatic diseases of a serious nature being unknown.

The following statistics concerning temperature, precipitation and snowfall at Bluefield, furnished by H. C. Howe, Meteorologist, United States Weather Bureau, Parkersburg, West Virginia, give the main climatological facts for the county, the average annual temperature being 53.8 degrees, the average precipitation 41.28 inches, and the average snowfall 37.6 inches:

Monthly, Annual, and Mean Temperature in Degrees Fahrenheit at Bluefield, Mercer County, West Virginia.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1893	22.1	34.0	41.0	54.2	60.0	69.2	73.2	69.4	64.4	53.1	42.6	36.3	....
1894	37.5	33.6	47.2	50.6	59.5	68.2	....	....	....	....	....	....	....
1895	28.6	23.3	40.8	51.1	60.9	70.1	69.5	73.5	71.3	49.6	47.1	37.0	....
1896	34.2	33.5	39.5	58.9	68.8	....	....	72.8	65.4	52.4	47.5	36.2	....
1897	30.4	38.2	47.1	53.4	58.3	71.8	73.0	70.7	66.6	58.7	47.2	39.1	....
1898	38.6	34.4	50.0	....	....	....	72.8	72.6	70.0	....	41.0	33.1	....
1899	35.2	28.4	43.7	52.6	63.9	69.1	70.3	71.6	63.4	57.8	46.2	32.8	52.9
1900	34.7	30.8	39.4	51.9	61.2	70.1	72.4	73.0	68.8	59.2	46.0	36.9	53.7
1901	34.3	29.1	43.4	46.6	60.8	68.8	73.6	70.3	63.0	53.2	37.2	32.7	51.0
1902	31.9	26.9	43.6	50.0	64.9	67.3	72.5	....	....	....	....	....	....
1903	34.6	41.4	51.4	57.3	65.7	65.8	71.3	73.3	64.8	....	....	28.2	....
1904	31.2	32.6	43.6	53.4	63.9	68.7	71.0	69.7	65.4	57.8	44.6	34.9	53.1
1905	27.8	26.7	49.2	56.4	65.4	70.4	72.7	67.8	66.3	55.4	....	35.8	....
1906	36.2	....	39.8	56.3	61.0	70.2	71.8	73.8	68.8	54.5	....	....	....
1907	44.0	32.8	....	....	....	....	....	....	....	....	....	....	....
1908	....	....	....	....	....	....	....	....	....	....	....	....	....
1909	37.4	40.0	42.0	54.8	60.2	70.2	68.8	70.0	62.6	51.6	49.8	81.1	53.2
1910	34.5	35.2	51.4	55.3	57.6	63.8	72.6	69.6	66.5	58.1	39.4	30.6	52.9
1911	38.9	40.4	42.5	49.5	66.2	70.2	71.0	73.4	70.1	57.7	41.6	41.3	55.2
1912	27.8	31.2	41.6	55.6	63.4	66.8	71.5	69.0	68.1	56.3	43.4	38.8	52.8
1913	44.2	37.2	47.0	53.8	62.8	68.4	73.6	72.6	64.0	54.8	48.9	38.9	55.5
1914	37.4	33.8	38.4	55.1	62.0	73.8	72.0	72.0	63.8	56.8	43.0	31.8	53.3
1915	33.2	40.1	34.8	55.8	63.2	67.0	70.3	69.2	66.5	57.3	46.7	35.3	53.3
1916	43.2	35.2	42.0	50.9	64.6	69.6	73.2	71.4	63.4	57.4	44.9	37.4	54.4
1917	38.8	33.6	54.2	....	54.4	66.6	70.3	69.8	63.1	49.4	42.0	26.9	....
1918	24.4	41.0	50.2	50.8	60.4	67.4	66.4	71.1	60.0	60.0	44.2	42.2	53.2
1919	36.7	36.6	45.6	52.4	62.0	70.6	72.8	67.8	65.2	63.8	47.1	35.2	54.6
1920	33.6	30.4	43.2	50.6	57.0	67.0	69.4	68.1	65.6	56.6	43.0	37.6	51.8
1921	36.4	39.6	55.0	55.6	60.3	71.8	73.3	70.0	70.3	54.3	48.4	40.7	56.3
1922	34.1	41.6	48.3	56.1	63.8	69.4	71.2	67.9	67.3	57.6	47.8	43.6	55.7
1923	39.6	36.0	46.1	54.2	62.5	70.8	71.0	70.2	66.8	54.4	45.4	48.2	55.4
Means	34.7	34.4	44.9	53.5	62.0	69.0	71.5	70.8	66.0	55.9	44.8	36.3	53.8

Monthly, Annual, and Mean Precipitation in Inches at Bluefield, Mercer County, West Virginia.

(Elevation, 2558 feet.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1891	....	....	....	....	....	....	....	....	....	2.48	4.29	....	....
1892	....	....	....	....	....	....	....	5.53	2.37	0.42	1.58	2.00	....
1893	1.47	4.92	2.83	4.15	7.85	6.41	3.18	6.82	4.31	7.22	1.93	1.68	52.76
1894	2.69	5.73	1.80	3.36	5.37	3.44	....	....	....	....	....	....	....
1895	5.75	1.44	3.83	5.18	3.90	3.84	6.58	4.16	1.18	1.93	2.13	3.27	43.19
1896	1.36	2.62	6.38	2.15	2.18	6.00	7.00	5.69	5.28	1.39	4.58	1.40	46.03
1897	1.78	6.28	4.74	1.58	4.43	4.39	6.78	2.34	0.62	0.65	1.42	3.50	38.51
1898	2.96	0.98	3.53	3.75	5.00	5.50	6.42	6.15	3.15	6.36	3.02	2.25	49.07
1899	2.20	6.43	6.27	2.76	6.02	5.34	4.09	3.25	2.28	1.23	1.08	3.83	44.78
1900	1.98	4.08	6.48	1.23	4.90	5.48	3.28	3.52	3.86	2.94	5.47	2.04	45.26
1901	3.35	1.03	2.39	8.28	8.86	10.87	3.28	9.92	1.68	1.05	1.55	7.77	50.03
1902	3.37	5.15	4.51	1.82	2.90	6.20	2.46	....	....	....	....	....	....
1903	5.30	4.45	4.53	3.75	1.20	3.97	2.61	2.00	0.10	1.70	2.20	1.94	33.75
1904	3.62	2.25	3.90	4.20	1.58	3.80	3.90	3.60	1.32	1.15	0.91	2.30	32.53
1905	3.43	2.42	1.48	0.81	7.67	3.20	6.10	4.50	1.80	2.90	0.70	3.50	38.51
1906	5.50	0.60	3.70	3.80	2.00	4.30	4.27	6.35	3.40	4.85	3.85	3.50	46.12
1907	2.65	3.25	....	....	....	8.86	....	....	....	....	....	....	....
1909	1.75	3.69	4.26	3.07	3.38	5.35	4.44	5.70	5.67	2.49	2.24	5.07	47.11
1910	3.14	2.57	0.24	4.04	3.50	2.85	4.61	2.59	3.53	2.51	1.80	2.00	33.38
1911	3.16	2.52	4.67	5.14	0.81	4.52	2.97	4.79	3.76	7.36	2.92	2.71	45.33
1912	2.55	2.38	4.99	5.59	4.03	7.49	5.50	4.70	2.79	1.87	1.49	1.91	45.29
1913	3.51	1.39	4.12	2.34	1.89	5.71	5.49	2.91	3.17	2.55	0.61	2.02	35.62
1914	3.90	2.10	3.90	1.29	0.70	0.62	3.35	3.62	1.46	2.41	1.47	2.73	27.55
1915	2.17	2.30	0.90	3.03	3.01	1.21	4.18	2.44	2.48	1.98	2.55	1.90	28.15
1916	2.37	3.35	3.09	1.90	0.90	2.99	3.12	2.81	1.01	2.16	1.85	2.40	27.95
1917	4.17	1.65	1.72	2.50	1.54	2.10	5.13	2.84	2.75	3.74	0.76	2.57	31.47
1918	4.06	1.84	4.11	4.80	3.28	6.05	2.23	2.05	3.68	4.61	1.61	3.88	42.20
1919	5.02	2.75	3.01	3.24	4.65	4.29	7.65	3.86	1.06	6.49	2.00	2.63	46.65
1920	3.73	4.06	3.88	4.05	3.15	4.25	3.35	8.29	3.80	0.44	5.35	3.84	48.29
1921	3.55	3.39	2.08	1.89	3.65	2.45	3.54	4.54	2.83	3.43	2.89	4.17	38.41
1922	3.13	4.23	4.52	3.19	2.36	7.38	6.86	1.91	1.03	4.81	0.93	6.39	46.74
1923	4.42	5.56	3.52	2.90	0.87	2.69	2.68	5.01	2.61	1.17	2.03	3.29	36.75
Means.	3.27	3.18	3.63	3.30	3.50	4.72	4.46	4.26	2.61	2.91	2.25	3.09	41.98

Average Monthly and Annual Snowfall, in Inches, for a Period of 27 Years, at Bluefield, Mercer County, West Virginia.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
11.1	8.0	7.2	1.3	0.1	....	....	....	....	0.5	2.0	7.4	37.6

Population.—The following table, taken from the United States Census returns for 1920, shows the population of Mercer County for the last three enumerations:

Population of Mercer County.

MINOR CIVIL DIVISION	1920	1910	1900
Beaver Pond District, including Bluefield City.	19,024	14,817	8,221
Bluefield city	15,282	11,188	4,644
East River District, including Oakvale town and Princeton city	10,374	6,096	3,499
Oakvale town	281	278	.....
Princeton city	6,224	3,027	.....
Jumping Branch District	1,045	1,122	1,214
Plymouth District, including Athens town	2,790	2,764	2,318
Athens town	552	575	.....
Rock District, including Bramwell and Matoaka towns	16,325	13,572	7,771
Bramwell town	1,696	1,458	825
Matoaka town	647	.....	.....
Totals for County	49,558	38,371	23,023

For the 20-year period covered by the above returns there is an increase in population of 110.9 per cent., as compared to 52.7 per cent. for the entire State during the same time interval. In density of population the county has 117.1 inhabitants per square mile, as compared to 59.8 for the entire State (the latter being figured on a State area of 24,497 square miles which the Survey regards as more accurate than the 24,022 square miles used in the Census).

Products. — The principal animal products are cattle, horses, sheep, hogs, poultry, mules and bees, their value being in the order named.

The principal agricultural products are corn, oats, wheat, buckwheat, hay, potatoes, apples, peaches, cherries and grapes, their relative value being uncertain.

The principal mineral and manufactured products now in a stage of development are coal, lumber, limestone, powder, castings, and flour.

Property Valuation.—According to Hon. John C. Bond, State Auditor, and R. C. McClaugherty, Assessor of Mercer County, the following table shows the property valuation for Mercer County for three years:

	1922	1923	1924
Real Estate	$29,111,000	$29,395,300	$30,881,530
Personal Property	14,689,699	13,726,559	14,008,613
Public Service Corporations	16,967,264	17,537,400	17,822,971
Totals	$60,767,963	$60,659,259	$62,713,114

Postal Service.—Mercer County is served partly by railway mail and partly by star route and rural free delivery carriers, there being two rural routes. City delivery is afforded in Bluefield and Princeton. The following table, compiled from the United States Official Postal Guide, shows the number of post-offices in the county, exclusive of Jumping Branch and Rock Districts, with which this Report is only incidentally concerned. Figures following the names of offices indicate the number of rural free delivery routes starting therefrom:

Ada	Ingleside	Oakvale
Athens	Kale	Pettry
Bluefield—1	Kellysville	Princeton—1
Elgood	Lerona	Speedway
Hatcher	Nemours	Willowton

TOWNS AND INDUSTRIES.

Princeton.

Princeton, the county-seat of Mercer, is situated on Brush Creek of Bluestone River in the south-central part of the county at a point where the valley of the stream widens locally into a broad plain, the elevation of which at the court-house is 2449 feet above sea-level, Harris[3] gives the following memorandum of its corporate history:

"Chartered by the General Assembly of Virginia in 1837, in 1909 the Legislature of West Virginia passed an act to amend the charter of 'The Town of Princeton' to incorporate the same as 'The City of Princeton,' and repealing all other acts relating to the old municipality. This charter was amended in 1913, 1915 and 1917, and in its entirety in 1923; elections held biennially in June."

From its first establishment as the county-seat of the new county of Mercer in 1837 the growth of Princeton appears to have been extremely slow for a period of nearly

[3]John T. Harris, West Virginia Legislative Handbook, p. 291; 1923.

70 years, its business having been mainly confined to county affairs and local commerce. Even as late as 1900 the Census gives no separate return of its population but with the advent of the Virginian Railway, the construction of which is described as having been completed through Mercer County in 1909, its growth has been rapid, the population in 1910 being 3,027 and being increased to 6,224 in 1920. In addition to the county business, which has now become large because of a greatly increased county population, the city benefits much by the presence of the shops and extensive yards of the Virginian Railway. It is also served by the local and interurban trolley lines of the Princeton Power Company which connect with Bluefield and Graham and there is a hard-surfaced road to these other cities as well as to Athens where a State Normal School is located.

Virginian Railway Shops.—The Virginian Railway maintains extensive shops at Princeton. According to Mr. J. W. Sasser, Superintendent of Motive Power, these shops include a roundhouse for steam locomotives, which was completed in 1909, there being 15 stalls and an operating force of 195 men of whom 142 are skilled mechanics; a car repair shop capable of holding 106 cars at a time, in which are employed 285 men of which 198 are skilled mechanics; an erecting shop, employing 436 men of whom 243 are skilled mechanics; and a reclamation plant, with a force of 26 men of whom 13 are skilled. The total average monthly pay-roll at the four shops is $106,000.

Bluefield.

Bluefield, the largest city in Mercer County, is situated in the extreme southern end of the county at the summit, or watershed, between East and Bluestone Rivers and near the northern base of the towering range of East River Mountain, the elevation above sea-level near the station being 2563 feet while the mountain reaches 3700 feet. It is one of the youngest cities of the State, its origin and development having been coincident with that of the Norfolk and Western Railway which was completed through the county

between 1881 and 1883, the statement being made by Johnston[4] that it was a mere flag-station in 1888 but that it was incorporated as a town in 1889. Harris[5] gives its further corporate history as follows:

> "Chartered originally under chapter 47 of the code, which charter was amended by special act of the Legislature in 1897; legislative charter amended in part in 1905 and 1907; in whole in 1909 and 1917; in part in 1919; in whole in 1921; governing body, a board of directors consisting of five members; city manager administrative head of municipal government which is non-partisan; election every four years, on the first Tuesday in July, unless the first Tuesday falls on the fourth when it shall be held on the following day; next election in 1925."

The information contained in the Handbook is further corroborated by a letter from William H. Thomas, present Mayor of Bluefield, but the statement is therein made that incorporation took place in 1890 instead of 1889 as recorded by Johnston; but according to H. D. Karnes, Clerk of the Circuit Court of Mercer County, the incorporation of the "City of Buefield" was made and the order entered November 20, 1889.

On account of the narrow valleys of East and Bluestone Rivers, the greater portions of which are occupied by the tracks and repair and operating plant of the railroad, the city has been built along the hill slopes for four miles parallel to the railroad, its southwestern limit being the Virginia State line, where the corporation of the City of Graham (renamed Bluefield, Virginia, in 1924), in Tazewell County, begins. In recent years, however, the need for more ground at Bluefield has caused the city to expand southward through a narrow defile to the headwaters of Beaver Pond Creek and to the limestone uplands which lie at the immediate base of East River Mountain, the two parts of the city being completely separated, except for the passage mentioned, by a comparatively low but steep ridge. In the southern portion, known as South Bluefield, there is a more ample amount of good building ground, which is now being covered with handsome homes and occasional business structures, its ex-

[4]David E. Johnston, History of the Middle New River Settlements and Contiguous Territory, p. 355; 1906.

[5]John T. Harris, West Virginia Legislative Handbook, p. 281; 1923.

tremely rapid growth being accompanied with paved streets and other improvements by the aggressive and intelligently directed city administration.

In the matter of transportation Bluefield is served by the main line of the Norfolk and Western Railway, by the local and interurban trolley lines of the Princeton Power Company, which provide city service and connection with Graham (now Bluefield), Virginia, and Princeton, West Virginia, and by the paved highway which connects Graham, Bluefield, Princeton, and Athens, with branches into the coal fields. In business the city profits greatly from the activities of the railroad, there being a large operating plant with extensive yards, and a repair department with facilities for handling much equipment, as hereafter described. Being the eastern end of the electrically operated section of the road a double supply of rolling stock is necessarily in use. The city also has an extensive jobbing and retail mercantile trade, being the natural supply point for much of the Pocahontas coal field as well as of a large tributary territory farther east; and it is the headquarters of many large operating coal companies with the attendant banks, foundries, electric repair shops and other works required to serve such business. Within or near its limits there are several limestone quarries which will be later described in Chapter XIV on "Limestone". In matters of education it has graded schools and an excellent high school, and is also the location of the Bluefield Colored Institute as later described, while just across the city line in Tazewell County, Virginia, is Bluefield College, the first buildings of which were erected in 1922.

The population of Bluefield in 1900 was 8,221; in 1910 it was 14,817; and in 1920 it had increased to 19,024.

Norfolk and Western Railway Shops.—The Norfolk and Western Railway Company maintains extensive repair shops at Bluefield. According to Mr. A. Kearney, Superintendent of Motive Power, Roanoke, Virginia, these Bluefield shops include a roundhouse for steam locomotives, there being 41 stalls and an operating force of 690 men of whom 452 are classed as skilled mechanics or laborers; and a car repair shop capable of holding 230 cars at one time, at which are

employed 283 men of whom 215 are skilled. At Bluestone, Mercer County, 11 miles west of Bluefield, there is an electric locomotive repair shop, built in 1915, and now employing 224 men of whom 148 are skilled mechanics and laborers. The total average monthly pay-roll at the three shops is $175,000.

Bluefield Institute.—Bluefield Institute, located in the western end of Bluefield, at the foot of Stony Ridge and just north of the main line of the Norfolk and Western Railway, is a State school built and maintained for the education of colored students. According to H. R. Sims, President, the bill creating the institution passed the Legislature in February, 1895, and the school was opened to students in December, 1896. The plant includes an administration building named Mahood Hall built in 1896, a girls' dormitory called Lewis Hall completed in 1897, and a boys' dormitory known as West Hall erected in 1900, together with 20 acres of land. The curriculum affords a secondary course of four years, a normal course of two years, a junior college course, besides courses in music, household economics and manual training, the last three being elective. The average number of resident students is 250 and the average number of extension students, including the summer school, is 300, all of them being supported by themselves or their parents without State aid. There are 20 teachers employed, the average monthly pay-roll being $3,348.36.

Athens.

Athens, situated in the plateau lands of eastern Mercer, with an elevation of 2597 feet above sea-level, and being six miles north of the city of Princeton, was incorporated as a town in 1906, its population by the Census of 1910 being 575, while in 1920 it had decreased to 552. It is joined with Princeton and Bluefield by a paved road, affording connection at the former point with the Virginian Railway and at the latter with the Norfolk and Western Railway. Although little more than a village it has always been an important community, being known during its early history as "Concord

PLATE II.—Athens, Mercer County, looking north from ridge one mile southward. Plateau surface on which town is built is Weverton Peneplain upheld by massive ledges of Hinton Group which form all the foreground. Ridge in rear is Bent Mountain covered by the Bluestone Group and being remnant of Schooley Peneplain. (Photo. by Palmer & Fowler).

Church". For a few years immediately following the Civil War of 1861-1865 it was the county-seat of Mercer County, the local government having been taken there by vote after the burning of Princeton in 1862, but before a court-house could be completed a subsequent vote restored the honor to Princeton. In 1872 an educational institution, now known as Concord State Normal School, was established in the village and since that time has been a constantly growing, cultural factor, as described below in more detail. Aside from this school the town is the supply point for a limited local community.

Concord State Normal School.—The Concord State Normal School, located on high ground within the town limits, is the principal feature of Athens. According to C. C. Rossey, President, this school was first established and opened for students May 10, 1875, his description of the property and scope of the school, as contained in a letter dated April 30, 1924, being as follows:

"First building, a wooden one, was erected in 1874. The Legislature of 1885 appropriated $5,000 for a brick building and in 1888 a further appropriation was made of $3,000 for an addition. In 1897 an appropriation of $20,000 was made for still larger additions. This building was burned in 1910. The present Administration Building was built with funds appropriated by the Legislature of 1911 and was erected in 1912. Two years later a large auditorium and laboratory were added. In 1891 a large wooden Dormitory for girls was built. It is now occupied by the young men, as a fine new brick Hall for Women has been built nearer the school building. This was erected in 1921. A Physical Education Building was erected in 1923-24 and is not yet finished, but can be used for athletics. The State owns about 40 acres of ground, of which the campus occupies nearly 30.

"We have four years of college work, and grant an A. B. Degree. We also give summer term work, at which time some preparatory work is offered. The average number of resident students for summer term is 585; first and second semesters, 134; spring term, 58. The average number of Correspondence and Extension students is as follows: Correspondence, 311; Extension, 108: The number of teachers employed is 17, with a monthly pay-roll of $5,250.16."

Oakvale.

Oakvale, situated on the northern side of East River in the southeastern part of Mercer County, at an elevation of 1712 feet above sea-level, was incorporated as a town in 1907,

according to J. R. Boyd, its present Mayor. In 1910 its population was 278 and in 1920 it had only increased to 281. It is located on the main lines of both the Norfolk and Western and Virginian Railways.

Villages.

Besides the four incorporated cities and towns above described, and in addition to cross-road post-offices containing only one or two families, the following are the most important villages of Beaver Pond, East River, and Plymouth Districts, with which portion of Mercer County this Report deals, their populations being counted or closely estimated by postmasters or other reliable parties:

Mercer County Villages.

(Beaver Pond, East River, and Plymouth Districts.)

Village	Population 1924	Village	Population 1924
Ada (a)	250	Kellysville (e)	500
Elgood (a)	15	Nemours (e)	325
Ingleside (e)	100	Willowton (Wills Station) (e)	50

(a) Actual count; (e) Estimate.

E. I. duPont de Nemours & Co.—The Nemours Works of the E. I. duPont de Nemours & Co., with its head office at Wilmington, Delaware, is located in a northern bend of Bluestone River, one-fourth mile northwest of Nemours Station and the same distance northeast of Nemours village. According to information supplied by the company through Ed. H. Ford, Director, the plant was built in 1904, its output consisting of black blasting powder with a daily capacity of 1,800 kegs of 25 pounds each, the product being mainly used in coal mining and principally consumed in the adjacent coal territory. Standard machinery for grinding and mixing the ingredients, pressing the powder and separating the grains, is employed, the same being run by electric power generated at the works. Practically all the raw material is imported from sources outside of West Virginia. Besides

the five salaried employees of the office and plant there are 54 male wage earners, of whom ten are skilled workmen, the average monthly pay-roll being $6000.

GENERAL DESCRIPTION, MONROE COUNTY.

MISCELLANEOUS ITEMS.

Formation. — Monroe County, comprising the eastern third of the area treated in this Report, and named in honor of James Monroe, Fifth President of the United States, was formed from Greenbrier by Act of the Virginia General Assembly, passed on January 14, 1799, the boundaries, as named in the Act, being quoted as follows by Morton:[6]

"Section 1. Be it enacted by the General Assembly, That all that part of the county of Greenbrier, lying within the following bounds, beginning where the ridge dividing the eastern and western waters joins Peters mountain, and with the said ridge to the ridge that divides Howards and Second Creek, thence with the said ridge westwardly, including the waters of Second Creek, to the wagon road at Robert Knox's; thence with the said creek to Thomas Nichol's spring branch, thence a straight line to Alderson's ferry landing on Greenbrier river, thence down the said river to the mouth of Muddy Creek, thence crossing the same to the ridge that divides the waters of Muddy Creek and Griffith's run, and with the said ridge to Keen's Knobs, and with the said knobs, including the waters flowing into Greenbrier River to New River, and up the same to where it breaks through Peters mountain, thence with the said mountain an easterly course to the beginning, shall form one distinct county, and be called and known by the name of Monroe."

Reduced to current nomenclature it is apparent from the sketch published by Morton and by Map III of this Report, that this line began at or near the triangulation point on Peters Mountain two miles southeast of Zenith, followed Peters Mountain northeastward to a point slightly over one mile south or southeast of Centennial; thence northwestward across Gap Mountain by way of the low divide east of Centennial to Roxalia; thence northeastward to Cove Mountain by way of the low divide southwest of Wylie Church; and thence apparently northeastward with Cove Mountain to the

[6]Oren F. Morton, History of Monroe County, West Virginia, pp. 105-106; 1916.

southern end of Grindstone Ridge; thence apparently westward with the present boundary to the mouth of Muddy Creek just west of Alderson. From this point to the top of Keeney Knob the original description is defective on account of the intervention of minor drainage between Muddy and Griffith Creeks, but from the top of Keeney Knob its course southwestward along the summit of Keeney Mountain and down to the mouth of Greenbrier River at Bellepoint is plain, as is also its coincidence with New River southward to the western end of Peters Mountain and thence northeastward with Peters Mountain to the beginning.

By Act of the Virginia General Assembly, passed January 2, 1802, approximately 150 square miles of territory was added to eastern Monroe, the boundaries being quoted as follows by Morton:[7]

"Beginning at the top of Middle Mountain, on the east side of Potts Creek, at the point where the Montgomery line intersects said mountain; thence down the top of said mountain as far as that point thereof which is opposite the lower end of David Edgar's plantation on the said creek; and thence with a straight line northwest on such bearing as will include Samuel Logue's plantation on Dunlap's Creek, and so continued on to the line of Greenbrier County.'

The "Middle Mountain" mentioned in the Act is evidently Potts Mountain and the expression "Down the top of said mountain" appears to mean a traverse northeastward along its summit, since Morton's map showing the line of 1802 so indicates it and his interpretation of the "Straight line northwest" makes the latter reach the Greenbrier line about two miles northeast of the present site of Alleghany Station.

Between 1806 and 1856 several boundary changes were made, the result being a net loss of territory from Monroe County. These changes are described as follows by Morton:[8]

"The above annexation moved the boundary much east of the divide between Eastern and Western waters and added about 150 square miles of territory. But four years later the process of subtraction began. Giles County, which became effective May 1, 1806, was formed from Montgomery, Monroe, and Tazewell, and was at the outset very much larger than at present. The original boundary on

[7] Ibid., p. 132.
[8] Ibid., pp. 132-134.

the northeast is defined as starting from the end of Gauley Mountain on New River at the intersection of the Greenbrier-Kanawha line, and running up New River with the Kanawha line to the intersection of the Monroe line. The line between Monroe and Montgomery is then followed to the upper end of Pyne's plantation, whence a straight line runs to the mouth of Rich Creek, leaving the plantation of Hugh Caperton to the right, and then follows the Monroe-Montgomery line to the Botetourt line.

"The next paring away was in 1822, when Alleghany county was formed out of Bath, Botetourt, and Monroe. The line between Monroe and the new county is described as starting from 'The top of the middle of Potts Mountain, where the Fincastle and Sweet Springs road crosses; then with the Sweet Springs road to the top of Peters Mountain; thence a straight course to the Greenbrier line on the top of the Alleghany, passing between Sweet Springs and Red Spring.' * * *

"In January, 1827, the court of Monroe was directed to have its surveyor mark that portion of the Monroe-Giles line beginning at Wray's path on the top of Peters Mountain opposite Andrew Allen's, and then running eastward, following the divide between Eastern and Western waters to Samuel Hutchinson's on the top of Middle, or Price's, Mountain, and with the same to the Betetourt line.

"A third trimming was authorized by the legislature (General Assembly) in February, 1829. Giles was enlarged at the expense of Monroe by a line starting on New River at the mouth of Ford Hollow Branch and running direct to Rich Creek at the bend adjoining Elias Hale's. Thence the line ran up Rich Creek to the mouth of Scott's Branch, and up the latter to the top of Peters Mountain. * * *

"Because the Greenbrier River made it troublesome to the people on Muddy Creek to attend muster at the court house, that portion of Monroe within the following lines went back to Greenbrier in 1827: From the mouth of Muddy down the Greenbrier to the mouth of Falling Branch; thence northwestwardly, leaving Thomas Griffith on the north and touching his land, to top of Keeney's Knob, where the proposed line intersects the previous county line. In 1811 an alteration here had been asked by Joseph Alderson, who was then sheriff.

"In 1835 there were 78 petitioners for a new county, to be taken from Monroe, Giles, and Fayette, but mostly from Monroe. The movement did not succeed, but in 1843 the whittling down of this county was resumed. In that year there was added to Alleghany all of Monroe outside of a boundary described as follows: Starting from the top of Peters, or Sweet Springs, Mountain and running to that point on the county line where Price's Mountain turnpike ceases to be the county line; thence a direct course crossing Potts Creek, to a sugar tree in James Wiley's yard; thence a direct course to where such line will strike Price's Mountain turnpike at the first ford of the run below Andrew Wilson's.

"Craig has nibbled into Monroe in 1853 and 1856. The first annexation was that part of Monroe east of a line beginning on the boundary of Craig at the top of Little Mountain and running with said line to a point opposite William A Rowan's; thence crossing Potts Creek to the top of Peters Mountain opposite the said Rowan's, and with the top of said mountain to the corner of Monroe. Three years later there was added to Craig a strip outside of a line beginning on Potts Creek where the Monroe-Craig line crosses (near William A. Rowan's); thence up the creek to past George H. Carpenter's, and then to the Craig line near Jarvis's."

In 1871 Summers County was formed by Act of the West Virginia Legislature and its boundaries, described later under an appropriate heading, took from Monroe County all the present areas of Forest Hill and Talcott Districts and the major part of Greenbrier District of the younger county. Since that date all subsequent attempts to reduce the territory of Monroe County appear to have failed.

Area.—The present area of Monroe County, as determined with planimeter by the writer from the topographic sheets of the United States Geological Survey, is as follows:

Monroe County Areas.

Districts	Square Miles
Red Sulphur	83.70
Springfield	87.96
Wolf Creek	52.69
Union	48.74
Second Creek	59.71
Sweet Springs	141.00
Total	473.80

Relief.—The surface of Monroe County varies in relief from 1450 feet above sea-level on New River at the extreme western tip of the county to 4050 feet at a high point on Peters Mountain, two miles south of Zenith, making a total difference of 2600 feet.

Climate.—The climate of Monroe County may best be described by dividing the area into two distinct zones, the first of which comprises the northwestern two-thirds and the second of which comprises the southeastern third including the range of Peters Mountain to the western end of the county. In the first zone the land is mainly a moderately elevated plateau, the general surface of which varies from 1900 to 2100 feet above sea-level and above which various ridges rise to a somewhat greater height while the major streams have cut channels a few hundred feet below the plateau level. In this region the summer heat is moderate and the winters are not unduly severe, and unseasonable frosts are rare. In the second zone the topography is mountainous, the summits generally ranging from 3,000 to 4,000 feet above sea-level

while the valleys, ranging from 1900 to 2500 feet, are narrow and lacking in climatic influence. In this region the atmosphere is perceptibly cooler and the summer season is shorter by two or three weeks. Throughout the entire county diseases incident to climate are generally unknown.

The following statistics concerning temperature, precipitation, and snowfall at Union, furnished by H. C. Howe, Meteorologist, United States Weather Bureau, Parkersburg, West Virginia, give the essential climatological facts for the county, the average annual temperature being 52.1 degrees, the average precipitation 38.06 inches, and the average snowfall 23.3 inches:

Monthly, Annual, and Mean Temperature in Degrees Fahrenheit at Union, Monroe County, West Virginia.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1902	....	....	....	....	....	....	....	....	....	....	....	36.2	....
1903	33.2	38.6	52.0	51.9	64.6	65.6	72.5	72.0	66.6	56.5	....	28.0	....
1904	31.0	32.3	44.8	48.6	61.1	69.0	70.6	70.5	66.8	....	....	....	....
1905	....	....	....	....	....	....	....	....	....	....	....	....	....
1906	40.4	37.7	43.0	57.8	63.2	....	70.0	74.5	68.6	51.2	40.3	35.6	....
1907	39.0	29.2	48.8	44.9	57.0	63.2	71.8	68.9	65.6	48.4	38.2	33.3	50.7
1908	26.2	28.1	46.0	52.2	62.0	66.7	70.8	69.0	61.3	52.8	39.9	....	...
1909	35.3	38.8	39.4	50.8	58.2	70.1	68.2	67.9	60.7	46.3	45.2	26.6	50.6
1910	30.6	31.4	46.8	50.8	56.2	64.0	70.4	68.0	66.1	54.4	35.0	26.2	50.0
1911	35.5	36.8	....	48.1	63.1	67.7	69.3	71.4	68.0	53.6	37.3	37.0	....
1912	21.3	25.2	39.8	52.9	61.2	66.0	70.4	....	66.2	52.8	....	....	....
1913	37.8	32.6	43.0	49.5	60.2	66.0	73.8	73.8	62.4	53.6	42.6	35.0	52.5
1914	34.6	30.2	37.0	51.8	60.7	71.5	72.2	71.4	63.7	57.2	39.4	29.4	51.6
1915	31.0	38.5	34.2	54.0	61.0	65.8	69.0	67.5	67.5	59.2	44.5	31.1	51.9
1916	37.3	31.8	38.2	49.3	63.0	65.0	73.2	71.4	62.7	54.2	41.0	30.9	51.5
1917	36.4	29.4	42.2	47.2	54.2	67.2	71.0	72.2	63.2	49.2	40.7	22.2	49.6
1918	20.4	35.0	47.2	49.2	67.0	67.8	76.0	....	....	56.6	41.4	39.6	....
1919	33.4	36.6	43.8	51.4	62.0	70.9	73.7	70.0	65.6	63.2	47.1	33.4	54.3
1920	30.4	31.4	41.6	50.2	58.4	66.8	69.8	70.5	66.6	57.0	41.8	33.9	51.5
1921	33.6	36.4	54.0	55.6	59.6	71.0	71.2	67.4	70.6	53.6	49.4	37.8	55.0
1922	32.8	39.4	47.7	57.0	63.0	69.8	72.4	68.5	66.6	55.4	43.2	39.0	54.6
1923	34.9	34.0	44.4	52.0	61.0	70.4	71.2	72.2	68.4	52.4	41.7	43.1	53.8
Means	34.5	33.6	43.9	51.3	60.8	67.6	74.8	70.4	65.6	54.1	41.7	33.2	52.1

Monthly, Annual, and Mean Precipitation in Inches, at Union, Monroe County, West Virginia.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1902	....	....	....	....	....	....	....	....	....	....	....	2.69	....
1903	2.96	4.94	4.49	4.12	0.80	2.01	4.99	2.34	0.99	1.82	2.00	1.13	32.59
1904	....	2.10	2.19	2.75	3.89	3.59	3.57	3.40	0.77	....	....	....	....
1905	....	....	....	....	....	....	....	....	....	2.89	....	3.08	....
1906	4.92	0.50	2.77	1.78	1.80	4.00	4.52	5.09	3.33	3.79	2.76	2.59	37.85
1907	3.34	4.09	3.71	3.25	1.67	4.75	4.38	2.57	4.15	0.57	3.94	3.55	40.37
1908	3.80	2.20	5.60	4.27	4.70	3.73	4.57	4.52	0.90	3.32	1.01	3.75	42.37
1909	3.00	2.36	4.11	2.62	3.74	4.98	5.73	2.63	4.35	3.41	0.85	1.35	39.13
1910	2.71	2.35	1.07	3.54	2.69	4.62	5.60	2.02	2.94	2.23	0.66	3.38	33.81
1911	5.36	1.43	4.65	2.19	1.02	4.59	1.29	6.98	2.06	4.85	3.06	2.44	39.92
1912	3.83	1.53	6.59	4.72	3.18	4.41	4.94	3.38	3.74	1.64	2.35	2.22	42.53
1913	4.38	1.98	5.89	4.05	2.95	6.03	2.97	2.97	2.47	3.11	1.91	1.10	39.81
1914	2.00	3.00	2.08	2.27	1.40	0.97	5.58	2.51	1.26	3.06	1.61	4.12	29.86
1915	3.84	3.49	0.79	0.69	4.02	1.97	7.08	3.55	4.22	2.70	2.13	1.90	36.38
1916	3.15	3.40	2.55	2.70	2.05	4.55	4.30	7.49	3.95	1.90	1.30	2.10	39.44
1917	2.75	5.10	8.00	2.00	3.60	2.64	3.27	3.10	2.75	3.03	0.40	1.98	38.62
1918	3.90	2.25	3.65	4.40	1.85	7.28	6.00	5.20	2.90	4.54	1.76	3.86	47.59
1919	2.92	3.10	2.75	2.20	5.59	7.26	5.35	2.66	1.70	5.15	2.10	2.60	43.38
1920	4.85	2.31	2.70	1.64	1.90	6.10	4.36	5.10	1.68	0.25	4.05	1.54	36.48
1921	1.40	2.36	0.63	1.49	2.83	4.12	3.78	2.32	3.09	3.85	3.52	3.24	32.63
1922	3.21	3.92	4.07	2.81	3.56	2.16	3.38	2.62	1.97	2.46	1.19	4.89	36.24
1923	2.85	3.14	3.71	3.03	3.07	2.76	4.83	4.93	2.65	0.66	3.07	4.08	38.78
Means	3.43	2.78	3.60	2.83	2.82	4.13	4.52	3.77	2.59	2.76	2.09	2.74	38.06

Average Monthly and Annual Snowfall, in Inches, for a Period of 17 Years, at Union, Monroe County, West Virginia.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
8.0	3.9	3.2	0.5	....	....	....	....	....	0.6	1.1	6.0	23.3

Population.—The following table, taken from the United States Census returns for 1920, shows the population of Monroe County for the last three enumerations:

Population of Monroe County.

MINOR CIVIL DIVISION	1920	1910	1900
Red Sulphur District, including Peterstown town	2,942	3,043	3,148
Peterstown town	293	257	167
Second Creek District	1,756	1,754	1,672
Springfield District	2,307	2,292	2,323
Sweet Springs District	2,459	2,137	2,065
Union District, including Union town	1,793	1,901	2,104
Union town	439	293	256
Wolf Creek District, including part of Alderson town	1,884	1,928	1,818
Alderson town (partly in Monroe and partly in Greenbrier County)	1,401	1,252	518
Totals for County	13,141	13,055	13,130

From the above figures it is evident that there has been only a nominal increase in population during the 20-year period covered by the returns, the lack of growth being accounted for by the complete absence of coal mines and large industrial plants such as have been developed within this interval in much of the remainder of the State. In density of population the county has 27.5 inhabitants per square mile, as compared to 59.8 for the entire State.

Products.—The principal animal products in Monroe County are cattle, horses, sheep, poultry, hogs, mules and bees, their value being in the order named. The cattle industry is preeminent, the great amount of limestone soil being especially suited for this purpose.

The principal agricultural products are corn, oats, wheat, buckwheat, hay, potatoes, apples, peaches, cherries and grapes, their relative value being uncertain.

The principal mineral and manufactured products are sulphur water, limestone and lumber. The sulphur waters, which have been widely exploited and which are a valuable resource, will be discussed in Chapter XV. The limestone, which is virtually inexhaustible, has been used only for local road building and as agricultural fertilizer. This natural

commodity will be discussed in Chapter XIV. The lumber industry, which was formerly of considerable importance, is now confined almost entirely to small portable mills.

Property Valuation.—According to Hon. John C. Bond, State Auditor, the following table shows the property valuation for Monroe County for three years:

	1922	1923	1924
Real Estate	$4,046,195	$3,982,790	$8,163,935
Personal Property	2,197,180	2,029,125	1,887,045
Public Service Corporations	774,546	774,556	805,295
Totals	$7,017,921	$6,786,471	$10,856,275

Postal Service.—With the exception of a small area, including the town of Alderson, which touches the Chesapeake and Ohio Railway, and of another comparatively small area in Potts Valley which is served by a branch line of the Norfolk and Western Railway, mail is entirely carried by automobile, by wagon or on horseback, there being rural free delivery or star routes from certain distributing centers. Mail for Union, the county-seat, is carried from Fort Spring, on the Chesapeake and Ohio Railway, by automobile during the summer months and by wagon in winter, and also by another route of similar character from the Virginian Railway at Rich Creek, Virginia. The following table, compiled from the United States Official Postal Guide, shows the number of post-offices in the county. Figures following the names of offices indicate the number of rural free delivery routes starting therefrom:

Alderson—1
Assurance
Ballard
Bozoo
Cashmere
Centennial
Creamery
Dorr
Elmhurst
Gapmills
Gates
Glace
Greenville—1
Hollywood
Keenan
Knobs
Laurelbranch
Lindside—1
Orchard
Peterstown—1
Pickaway
Red Sulphur Springs
Rock Camp
Roxalia
Salt Sulphur Springs
Sarton
Secondcreek
Sinks Grove—1
Sweetsprings
Union
Waiteville
Wayside
Wikel
Willow Bend
Wolfcreek
Zenith

TOWNS AND INDUSTRIES.

Union.

Union, the county-seat of Monroe County, was established as such by Act of the Virginia General Assembly in 1799, but according to John A. Campbell, its present Mayor, it was not formally incorporated as a town under the West Virginia laws until July 14, 1868. In 1900 its population was 256, in 1910 it was 298, but in 1900 it had increased to 439. Situated at an elevation of 2070 feet above sea-level in the rolling limestone lands which are typical of the central part of the county the town has an atmosphere of rare charm which is often wholly lacking in more active, industrial communities. To the west, beyond a gentle valley and less than three miles distant, is the isolated plateau of Swoopes Knobs rising more than 1200 feet higher than the town, while four miles southeastward, across a wide belt of limestone, the Alleghenies are in plain view with Little Mountain in the foreground and with the great escarpment of Peters Mountain forming an unbroken background. On account of its isolation the town has no industrial plants, its support being almost wholly derived from the county business, stock raising and mercantile pursuits.

Alderson.

Alderson, the largest town in Monroe County, is situated in the extreme northwestern corner along the Greenbrier River with an elevation above sea-level of 1555 feet, being partly in Monroe and partly in Greenbrier County. Harris[9] states that it was incorporated in 1899 under Chapter 47 of the Code of West Virginia, but that in 1902 the charter was amended to take in that portion of the town lying in Greenbrier County. In 1900 the population, as then limited to Monroe County, was 518; in 1910 the part in Monroe was 575 and that in Greenbrier was 677, making a total of 1252; in 1920 the part in Monroe had 560 and that in Greenbrier

[9]John T. Harris, West Virginia Legislative Handbook, p. 280; 1923.

841, making a total of 1401. Transportation is afforded by the main line of the Chesapeake and Ohio Railway which follows the south bank of Greenbrier River. The principal business consists in supplying the needs of the rich farming community which surrounds the town.

Peterstown.

Peterstown, situated on Rich Creek in the extreme southwestern corner of the county at an elevation of 1612 feet above sea-level, was incorporated as a town in January, 1922, according to T. E. Ballard, Recorder. Further data on its history are afforded by R. M. Humphrey, Clerk of the Circuit Court of Monroe County, who states that the town was originally chartered in 1804 but that this early charter was forfeited at some later date so that the action of 1922 was in effect a reincorporation. In 1900 its population was 167, in 1910 it was 257 and in 1920 it was 293. Railway transportation is afforded by the main line of the Virginian Railway at Rich Creek Station, Virginia, less than two miles distant, and by the main line of the Norfolk and Western Railway at Narrows, little more than five miles by automobile road. Its principal business is derived from the farming community which surrounds it.

Villages.

Besides the three incorporated towns above described, and in addition to cross-road post-offices that contain only one or two families, the following are the most important villages of Monroe County, their populations being counted or closely estimated by postmasters or other reliable parties:

Monroe County Villages.

Village	Population 1924	Village	Population 1924
Ballard (a), (b)	359	Red Sulphur Springs (e)	60
Cashmere (a), (b)	134	Rock Camp (e)	50
Gap Mills (a)	110	Salt Sulphur Springs (a)	17
Gates (a)	22	Second Creek (a)	85
Greenville (e)	150	Sinks Grove (a)	110
Keenan (a), (b)	125	Sweet Springs (e)	125
Laurel Branch (a)	184	Waiteville (e)	50
Lindside (a)	65	Wayside (a)	25
McGlone (e), (c)	125	Wikel (e)	35
Pickaway (e), (b)	100		

(a) Actual count; (e) Estimate; (b) Appears to include all post-office population; (c) Post-office discontinued.

GENERAL DESCRIPTION, SUMMERS COUNTY.

MISCELLANEOUS ITEMS

Formation.—Summers County, which is a wedge-shaped area that almost entirely separates Mercer and Monroe and which is the most northern of the three, was formed from parts of Monroe, Mercer, and Greenbrier Counties by Act of the West Virginia Legislature passed February 27, 1871, its boundaries being named as follows:[10]

"Be it enacted by the Legislature of West Virginia:

1. So much of the counties of Monroe, Mercer, Greenbrier and Fayette as is included within the following boundary lines, to-wit: Beginning at the mouth of Round Bottom Branch of New River, in Monroe County; thence crossing said river and running N. 47° W., 5,430 poles, through the county of Mercer, to a point known as Brannon's Gate,' on the line dividing the counties of Mercer and Raleigh; thence with said county line in an easterly direction to New River; thence with a line between the counties of Raleigh and Greenbrier, down New River to the line of Fayette county; thence with the line dividing Raleigh and Fayette counties, down said river to a station opposite Goddard's house; thence leaving the line of Raleigh county, crossing New River, passing through said Goddard's house, N. 67° E., 3,280 poles, through said county of Fayette to a station of 'Wallow Hole' Mountain in Greenbrier County; thence S. 55° E., 3,140 poles to a station east of 'Keeny's Knob,' in Monroe county; thence S. 9° E., 1,320 poles to a station near Greenbrier river, and running thence S. 32° W., 7,740 poles to the beginning, shall form one distinct and new county which shall be called and known by the name of Summers county, and it is expressly understood and agreed by the applicants therefor that no part of the territory of the county of Raleigh shall ever be attached to the county created by this act."

[10]West Virginia Acts of 1871, p. 178.

Subsequent to the passage of the original act of formation there have been boundary disputes with both Monroe and Greenbrier Counties in the territory adjacent to Alderson but these have been adjudicated. So far as known no other changes or disputes concerning the boundaries have occurred.

Area.—The present area of Summers County, as determined with planimeter by the writer from the topographic sheets of the United States Geological Survey, as assembled on Map V, and including Jumping Branch District previously described by C. E. Krebs in the Raleigh County Report of the Survey, is as follows:

Summers County Areas.

Districts	Square Miles
Green Sulphur	92.41
Greenbrier	38.38
Talcott	60.10
Forest Hill	49.36
Pipestem	54.20
Jumping Branch (Described in Raleigh County Report)	73.31
Total	367.76

Relief.—The surface of Summers County varies in elevation from 1240 feet above sea-level on New River at the common corner of Fayette, Raleigh, and Summers Counties to 3945 feet at the top of Keeney Knob on Keeney Mountain five miles northwest of Alderson, making a total difference of 2705 feet. At nearly all points in the county there is large local relief due to the fact that the ancient plateau has been much eroded by the channels of streams.

Climate.—The climate of Summers County is of the healthy and invigorating type, the average temperature at Hinton being slightly higher than that of Bluefield or Union, and its valleys are much more protected from western winds than the high plateaus of the other two counties, so that the contrast is even more marked than is indicated by the temperature charts. Climatic diseases and the somewhat oppressive humidity of the Ohio Valley region are comparatively unknown.

The following statistics concerning temperature, precipitation, and snowfall at Hinton and Green Sulphur Springs, furnished by H. C. Howe, Meteorologist, United States Weather Bureau, Parkersburg, West Virginia, give the main climatological facts for the county, the average temperature for both points being 53.25 degrees, the average precipitation 39.17 inches, and the average snowfall 25.45 inches:

Monthly, Annual, and Mean Temperature in Degrees Fahrenheit, at Hinton, Summers County, West Virginia.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	30.3	26.1	44.2	54.8	63.1	69.4	72.3	74.2	70.6	50.0	46.8	39.4	....
1896	35.6	36.9	40.6	59.6	71.1	71.2	70.9	74.2	67.2	53.1	49.1	35.7	....
1897	30.3	39.6	48.6	53.6	60.8	71.4	75.6	72.5	66.0	59.4	46.2	36.6	....
1898	38.8	33.8	49.3	49.8	65.2	72.0	76.4	74.4	69.4	56.3	42.2	43.3	55.1
1899	34.4	28.4	44.8	54.4	67.2	73.4	75.5	76.6	67.3	58.9	46.7	32.9	55.0
1900	34.7	32.4	41.8	53.0	59.9	....	75.8	76.6	71.4	61.4	46.4	36.6	....
1901	....	30.4	43.6	48.3	62.2	72.2	76.6	72.2	65.6	54.9	40.6	33.4	....
1902	31.0	29.6	44.4	50.8	67.1	....	75.2	71.8	65.8	57.4	49.2	36.7	....
1903	33.6	38.7	53.1	51.4	65.4	66.0	74.1	73.5	65.6	57.4	40.2	28.8	54.0
1904	....	....	....	....	....	....	....	....	....	....	....	....	....
1905	....	....	....	....	....	....	....	....	....	....	....	....	....
1906	39.7	36.1	41.6	57.2	....	71.9	73.5	76.6	71.6	54.6	46.2	36.8	....
1907	42.7	34.8	52.4	48.0	61.2	66.4	75.0	.. .	68.2	53.4	44.3	37.0	....
1908	31.7	32.0	50.5	56.8	63.8	70.9	....	....	66.8	55.9	44.6	37.0	....
1909	38.2	42.8	43.2	55.3	62.2	72.2	71.6	....	65.4	52.0	48.2	....	....
1910	....	....	....	....	....	....	....	71.9	71.4	59.6	38.3	29.6	....
1911	37.6	40.6	41.2	50.4	66.8	72.0	73.8	75.7	72.8	58.9	41.0	39.1	55.8
1912	24.5	29.8	41.9	56.8	64.8	69.6	75.1	71.8	71.6	59.4	42.4	35.6	53.6
1913	41.9	35.6	45.4	53.1	63.6	72.4	76.4	75.5	65.7	55.4	44.6	38.2	55.6
1914	35.0	31.3	38.6	53.6	64.2	75.4	75.6	74.2	65.8	58.8	41.2	31.2	53.7
1915	31.6	39 0	34.8	55.2	63.2	68.6	73.4	72.4	69.6	58.8	44.6	33.2	53.7
1916	37.6	32.9	39.4	50.8	65.6	68.1	75.0	73.8	64.3	54.4	42.4	30.9	52.9
1917	35.2	30.4	43.2	53.0	56.2	68.7	73.6	72.8	64.8	48.3	40.6	23.0	50.8
1918	21.0	35.5	47.4	49.6	67.0	68.6	70.8	75.8	61.2	58.0	42.6	40.0	53.1
1919	34.0	34.4	44.8	51.7	62.4	73.4	74.5	70.8	67.2	64.3	46.6	31.4	54.6
1920	32.0	30.7	42.6	49.6	59.6	67.2	70.0	70 2	67.4	57.4	40.8	36.6	52.0
1921	35.6	39.7	55.1	56.3	62.1	71.5	75.0	71.2	73.8	55.3	47.3	38.8	56.8
1922	32.0	49.0	46.2	56.1	63.9	70.6	73.1	69.2	69.2	57.6	40.6	38.2	54.6
1923	36.8	34.0	44.2	52.9	61.8	71.8	72.4	73.0	69.0	55.4	43.1	44.1	54.9
Means	34.2	34.4	44.7	53.2	63.6	70.6	74.0	73.4	68.0	56.5	44.0	35.5	54.1

Monthly, Annual, and Mean Temperature in Degrees Fahrenheit at Green Sulphur Springs, Summers County, West Virginia.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	29.6	24.2	41.4	52.5	61.5	71.0	72.1	74.0	72.0	46.7	42.6	38.4	....
1896	31.1	32.2	39.4	57.0	69.2	70.8	74.2	74.2	67.2	53.2	50.4	33.9	....
1897	30.3	37.2	47.2	52.0	59.1	69.8	73.7	70.6	65.0	56.7	45.8	37.7	....
1898	39.2	32.4	49.2	48.0	60.7	69.8	74.7	74.3	68.4	56.1	41.9	32.7	54.0
1899	34.0	27.8	43.4	51.0	64.1	72.0	75.0	75.0	64.9	....	46.2	32.8	53.1
1900	35.6	32.2	40.9	51.3	62.2	73.0	75.6	74.6	70.5	60.1	45.6	34.8	54.7
1901	32.4	26.4	40.4	45.9	60.0	69.2	76.1	70.6	64.1	52.6	34.4	31.4	50.2
1902	29.7	29.1	41.4	48.3	63.2	66.4	69.4	69.2	61.0	54.9	48.0	32.2	51.1
1903	31.1	33.8	50.7	48.8	62.8	65.0	71.2	71.6	64.4	51.8	37.9	36.8	51.3
1904	28.6	31.3	42.7	47.8	61.0	68.2	69.0	68.8	65.0	53.0	41.8	32.4	50.8
1905	25.7	25.3	46.9	51.5	63.0	68.7	70.8	69.2	64.4	54.8	41.6	35.5	51.4
1906	38.2	36.8	37.8	53.2	60.2	68.2	71.8	75.5	68.0	54.2	44.2	35.6	53.6
1907	40.4	33.4	50.8	45.5	55.6	61.5	72.2	70.2	....	51.2	41.0	34.6	....
1908	28.8	29.6	48.0	55.8	62.8	69.1	72.0	67.8	64.1	54.4	43.5	36.0	52.7
1909	37.2	41.8	....	....	....	....	....	....	....	....	....	....	....
1910	....	30.2	....	50.0	56.8	66.4	74.0	70.2	67.8	57.4	36.9	29.2	....
1911	37.5	39.2	41.0	49.4	64.6	69.4	70.4	72.5	69.8	57.6	39.9	38.6	54.2
1912	23.4	29.8	41.0	55.1	62.0	66.4	72.0	68.8	68.2	55.8	40.6	34.6	51.5
1913	40.6	34.6	46.0	52.1	61.1	68.8	73.4	72.4	63.4	53.4	44.2	36.6	53.9
1914	34.8	30.8	37.6	52.2	61.5	72.6	72.0	71.6	63.0	56.4	41.2	31.0	52.1
1915	31.8	38.0	33.9	53.6	62.1	67.0	70.8	69.1	67.6	56.7	44.0	32.3	52.2
1916	38.8	32.8	38.7	50.0	63.6	65.4	72.6	72.6	63.7	53.2	43.8	30.7	52.2
1917	33.1	31.8	46.2	....	56.0	71.4	74.4	....	....	....	....	26.6	....
1918	25.1	35.8	47.2	49.4	63.8	67.6	....	....	....	56.3	44.4	....	....
1919	....	34.6	43.4	50.3	59.4	....	....	....	....	....	....	....	....
1920	33.9	32.1	43.2	50.4	58.5	66.9	70.8	....	....	....	....	35.0	....
1921	35.4	38.9	54.4	55.2	60.0	71.3	74.3	....	....	52.0	48.1	38.4	....
1922	32.3	40.2	47.2	56.0	63.3	70.0	73.2	....	....	55.8	45.6	38.6	....
1923	36.2	33.2	43.6	50.6	60.4	....	....	....	....	....	....	....	....
Means	33.1	32.9	43.8	51.2	61.4	68.7	72.5	71.6	66.1	54.5	43.0	33.9	52.4

Monthly, Annual, and Mean Precipitation in Inches, at Hinton, Summers County, West Virginia.

(Elevation, 1450 Feet)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1889	2.07	1.19	1.04	1.91	5.70	3.50	4.50	3.25	4.18	1.34	2.17	1.00	31.85
1890	....	....	....	3.78	4.40	4.00	3.47	3.49	2.17	4.06	0.84	3.29	....
1891	2.36	6.38	6.18	2.39	5.01	3.15	2.47	4.62	0.48	1.53	2.09	2.51	39.17
1892	3.02	2.23	3.71	5.77	3.36	2.64	3.17	2.74	1.32	0.21	3.95	2.32	34.44
1893	1.87	5.52	1.64	4.35	5.56	7.02	2.30	3.32	4.50	5.17	1.20	1.04	43.49
1894	1.82	3.77	1.34	1.97	2.35	3.80	1.82	1.58	2.59	2.14	1.03	2.77	26.98
1895	5.06	1.00	3.20	4.12	4.05	2.50	6.44	3.21	4.37	1.06	1.82	2.01	38.84
1896	0.92	3.16	5.46	2.64	3.97	5.87	4.35	2.08	3.91	1.03	3.79	1.55	38.73
1897	1.55	7.08	4.59	2.03	3.56	3.42	5.03	2.55	0.34	0.76	1.00	3.76	35.67
1898	3.31	0.91	4.15	2.30	4.44	2.80	5.34	8.45	2.90	4.58	2.32	1.94	43.44
1899	2.96	4.88	7.05	2.07	5.32	4.68	1.25	2.45	3.56	0.71	1.27	2.49	38.67
1900	2.26	3.31	4.86	1.56	2.96	6.22	3.35	3.24	3.84	2.42	5.68	1.71	41.41
1901	3.56	0.78	2.60	6.85	5.91	6.30	2.85	8.54	2.29	0.69	1.40	7.85	49.62
1902	4.14	3.64	4.32	1.93	3.07	4.25	1.33	1.93	1.50	2.25	2.39	3.30	34.05
1903	3.49	5.56	4.96	3.54	1.91	3.53	3.22	3.42	0.42	1.62	2.24	1.33	35.24
1904	2.14	2.26	2.48	2.46	3.53	3.55	2.41	4.87	1.19	0.54	1.64	2.87	29.94
1905	2.49	3.97	2.56	2.17	5.13	2.92	5.91	3.09	1.96	2.93	1.62	2.89	37.64
1906	5.90	1.00	3.98	3.07	2.56	3.45	3.85	4.62	3.01	3.60	4.24	2.62	41.90
1907	3.01	3.04	4.25	4.29	2.30	7.24	3.16	4.44	4.99	1.87	4.03	4.08	46.70
1908	3.10	2.16	5.70	5.88	5.84	3.04	3.90	2.92	0.66	4.28	1.81	3.56	42.85
1909	2.24	3.02	4.97	2.71	4.40	4.80	5.54	3.34	5.28	2.66	1.14	2.72	42.82
1910	3.30	1.36	2.04	4.06	3.39	5.00	4.77	2.38	5.31	1.42	1.20	2.23	36.46
1911	4.44	2.52	4.66	4.01	1.28	4.28	2.08	5.47	1.80	6.08	2.96	2.62	42.20
1912	2.42	1.34	6.14	4.82	4.86	5.60	2.98	4.00	3.16	1.96	1.36	2.54	41.18
1913	3.58	2.40	4.88	1.90	4.34	2.58	4.08	1.46	3.16	3.85	2.59	2.74	37.56
1914	2.93	4.12	3.66	3.30	1.28	1.75	4.81	4.47	1.12	2.40	1.24	5.26	36.34
1915	4.46	2.78	1.99	2.08	3.21	2.62	3.34	2.68	2.92	3.85	2.17	3.35	35.45
1916	3.64	4.00	3.27	2.86	2.50	4.74	6.22	6.81	3.36	2.00	1.66	2.62	43.08
1917	3.28	4.04	8.47	2.10	3.86	2.34	5.02	1.96	4.94	3.28	0.72	1.64	41.65
1918	5.75	2.00	4.56	4.76	2.82	4.77	5.38	5.08	2.92	6.02	1.22	3.20	48.48
1919	4.22	2.46	2.80	2.32	5.00	8.04	8.26	4.64	1.26	5.20	3.44	3.58	51.22
1920	4.32	2.70	3.92	4.82	2.92	4.98	3.72	6.58	3.06	0.46	4.78	2.22	44.48
1921	1.93	3.30	1.12	2.22	2.94	6.28	4.04	2.78	3.12	2.76	4.10	4.26	38.85
1922	3.34	4.02	5.80	2.52	3.68	6.36	4.40	3.50	1.26	2.36	0.64	5.36	43.24
1923	3.57	3.18	3.42	3.33	2.56	4.60	6.46	4.20	2.02	1.16	2.91	2.68	40.03
Means	3.19	3.09	3.99	3.23	3.71	4.36	4.03	3.83	2.71	2.52	2.23	2.91	39.80

Monthly, Annual, and Mean Precipitation in Inches, at Green Sulphur Springs, Summers County, West Virginia.

(Elevation, 1600 Feet)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	3.30	0.75	2.56	3.44	1.67	2.55	3.16	3.11	2.18	0.75	0.75	0.75	24.97
1896	0.74	1.50	4.51	0.84	2.45	4.38	2.91	1.10	1.90	0.53	3.49	1.91	26.26
1897	1.10	7.21	3.92	1.76	3.05	4.62	1.98	0.85	0.02	0.29	1.04	2.88	31.72
1898	2.24	0.86	2.58	1.85	3.60	2.13	1.62	4.40	0.80	3.04	1.21	2.63	26.96
1899	2.53	5.51	6.15	1.55	5.82	6.32	0.94	1.57	3.62	0.75	0.74	2.91	38.41
1900	2.19	3.58	....	0.75	4.32	5.36	3.17	2.42	2.50	1.99	5.97	2.25	....
1901	3.20	0.62	1.73	7.27	8.36	4.86	3.53	5.94	1.65	0.53	1.54	6.42	45.65
1902	4.28	2.82	3.30	1.53	2.64	3.68	1.68	1.15	2.63	1.11	2.69	2.01	29.52
1903	2.81	4.74	3.65	3.43	1.83	3.23	3.34	2.26	0.59	1.96	1.60	0.61	30.05
1904	1.98	1.87	2.37	2.20	4.09	5.16	1.38	3.46	1.24	0.40	1.24	1.69	27.08
1905	1.56	3.04	1.88	1.51	5.28	2.78	6.49	2.01	1.61	2.52	1.83	2.62	33.13
1906	5.41	0.73	4.52	2.51	1.79	2.84	4.81	6.00	3.64	2.66	2.49	2.78	40.18
1907	5.42	1.60	3.98	3.90	2.55	7.41	5.24	4.30	4.50	1.92	3.95	2.89	47.66
1908	2.47	1.77	5.81	6.03	3.75	3.31	5.84	3.24	0.26	2.15	0.74	2.30	37.67
1909	1.51	2.35	4.90	2.75	3.80	3.00	5.00	2.80	4.00	2.75	1.15	2.50	36.51
1910	3.60	2.02	0.10	7.23	3.55	5.84	4.80	2.90	5.48	1.84	1.76	1.99	41.11
1911	5.40	1.86	4.91	5.66	1.51	4.97	3.60	4.52	2.03	5.43	2.92	2.26	45.07
1912	2.40	1.36	5.43	4.55	4.39	4.18	4.90	2.81	2.46	1.65	1.51	1.67	36.41
1913	3.54	1.60	4.11	1.61	3.32	2.52	3.64	2.31	2.78	3.99	2.97	2.28	34.67
1914	3.26	2.77	2.94	3.56	1.23	2.44	4.79	4.24	1.04	2.28	1.54	5.32	35.41
1915	3.24	2.60	1.40	3.85	3.00	2.24	3.30	5.01	4.09	3.60	2.85	3.22	38.40
1916	3.55	5.05	4.76	3.35	3.10	4.20	5.28	5.26	5.05	1.25	1.48	3.95	46.28
1917	5.03	5.20	8.00	....	5.06	4.50	4.50	....	....	....	....	2.40	....
1918	....	2.85	4.44	5.53	4.71	5.87	....	....	....	7.53	2.80	....	....
1919	....	3.93	4.81	2.33	6.35	....	....	....	....	....	....	....	....
1920	....	4.39	8.87	6.84	3.91	5.81	4.25	....	....	....	....	3.76	....
1921	3.48	4.42	2.23	5.09	4.81	4.37	1.62	....	....	3.80	5.22	6.96	....
1922	3.25	4.35	5.62	3.48	4.58	4.21	5.04	....	....	1.03	1.21	6.20	....
1923	6.14	4.47	3.92	3.61	3.28	....	....	....	....	....	....	....	....
Means	3.22	2.96	4.05	3.50	3.72	4.18	3.80	3.26	2.46	2.23	2.19	2.97	38.54

Average Monthly and Annual Snowfall in Inches at Green Sulphur Springs for a Period of 25 Years and at Hinton for 24 Years; both in Summers County, West Virginia.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Green Sulphur Springs..	7.7	7.3	4.4	1.4	....	....	....	....	....	0.1	1.2	5.9	28.0
Hinton..	7.0	4.9	4.3	1.1	T	....	....	....	....	0.2	1.3	4.1	22.9

Population.—The following table, taken from the United States Census Returns for 1920, shows the population of Summers County for the last three enumerations:

Population of Summers County.

MINOR CIVIL DIVISION	1920	1910	1900
Forest Hill District	1,469	1,584	1,601
Green Sulphur District	3,579	3,139	2,747
Greenbrier District, including Avis town and Hinton city	6,998	6,419	4,940
Avis town	1,635	1,432	.....
Hinton city	3,912	3,656	3,763
Jumping Branch District	2,774	2,797	2,779
Pipestem District	1,731	1,621	1,779
Talcott District	2,541	2,860	2,419
Totals for County	19,092	18,420	16,265

For the 20-year period covered by the above returns there is an increase in population of 17.4 per cent., as compared to 52.7 per cent. for the entire State during the same time interval. In density of population the county has 51.9 inhabitants per square mile, as compared to 59.8 for the entire State.

Products.—The principal animal products of Summers County are cattle, horses, sheep, poultry, hogs, mules and bees, in the order named.

The principal agricultural products are corn, oats, wheat, buckwheat, hay, potatoes, apples, peaches, cherries and grapes, their relative value being uncertain.

The principal mining and manufactured products are coal, building stone, limestone, mineral waters and lumber. The coal has been exploited but little, there being only one commercial mine. The building stone industry is dormant, and the limestone has been used only for local agricultural purposes, the outcropping area of pure limestone being quite small as compared to the deposits of Mercer and Monroe Counties. Salt was formerly manufactured on New River but this was long ago discontinued. Some of the mineral springs of the county are much frequented for the curative effect of their waters which are also shipped away in considerable quantity. The lumber industry is now largely, although not entirely, confined to small portable mills.

Property Valuation.—According to Hon. John C. Bond, State Auditor, the following table shows the property valuation for Summers County for three years:

	1922	1923	1924
Real Estate	$8,188,590	$8,011,860	$7,785,740
Personal Propoerty	2,634,874	2,548,492	2,186,555
Public Service Corporations	5,463,945	5,445,913	5,354,721
Totals	$16,287,409	$16,006,265	$15,327,016

Postal Service.—Summers County is served partly by railway mail and partly by star route and rural free delivery carriers, there being only one rural route. City delivery is afforded in Hinton. The following table, compiled from the United States Official Postal Guide, shows the number of post-offices in the county, exclusive of Jumping Branch District, with which this Report is only incidentally concerned. Figures following the names of offices indicate the number of rural free delivery routes starting therefrom:

Ballengee	Indian Mills	Pence Springs
Bellepoint	Judson	Pipestem
Bertha	Junta	Ramp
Brooks	Lick Creek	Sandstone
Buck	Lockbridge	Secoma
Claypool	Lovern	Seminole
Clayton	Lowell	Talcott
Crumps Bottom	Mandeville	Tophet
Elton	Marie	True
Forest Hill	Meadow Creek	Warford
Green Sulphur Springs	Neponset	
Hinton—1	Packs Ferry	

TOWNS AND INDUSTRIES.

Hinton.

Hinton, the county-seat of Summers County, is situated on the east side of New River 1½ miles north of the mouth of Greenbrier River and near the geographical center of the county, the elevation above sea-level at the Chesapeake and Ohio Railway Station being 1385 feet while that at the courthouse (which is on the high terrace that holds the major portion of the city) is approximately 1465 feet. According to S. S. Abbott, the present Mayor, it was incorporated as

a town September 21, 1880, under the general State laws. It later became a city by special enactment, as is detailed by Harris[11] in the following memorandum:

"Chartered in 1897 by special act of the Legislature; amended in 1901; amended in 1915 and commission form of government provided for; charter again amended in 1919. Elections biennially on the second Tuesday of December."

By the Census of 1900 the population was 3,763, in 1910 it was 3,656, and in 1920 it was 3,912. Besides the county business it is the mercantile supply center for most of Summers County and is an important operating point on the main line of the Chesapeake and Ohio Railway, which traverses the eastern bank of New River and which maintains repair shops there.

Chesapeake and Ohio Railway Shops.—The Hinton Shops of the Chesapeake and Ohio Railway, located north of the station at Hinton, are the principal industrial activity of the city. According to G. W. Robertson, Master Mechanic, these shops were completed August 1, 1892, and consist of a roundhouse with 17 engine stalls and a car repair shop holding 40 cars. In the roundhouse 370 men are employed, of whom 225 are classed as skilled workmen; and in the car shop there are 107 men, of whom 107 are skilled craftsmen. The average monthly pay-roll for all amounts to about $84,000.

Avis.

Avis, lying principally on the low flood-plain of New River immediately south of, and adjoining the city of Hinton, is an independent municipality although using the same post-office and railroad station as Hinton. The following letter from W. A. Wykel, the present Mayor, indicates its corporate history:

"The City of Avis was first incorporated under the name of Town of Upper Hinton by the Circuit Court of this county on the 3rd day of September, 1890, and was changed to City of Avis by an order of the same court on May 20th, 1901. Some years later it was joined to Hinton by an act of the Legislature and after a year or two was

[11]John T. Harris, West Virginia Legislative Handbook, p. 286; 1923.

divorced from Hinton and resumed the name of the City of Avis, but I have not the dates of this action. Again in 1900 by an act of the Legislature creating the Hinton Independent School District Avis was made a part of Hinton. This bill was declared unconstitutional by the court so we again reverted to our former name of City of Avis, West Virginia."

According to the Census returns Avis had a population of 1432 in 1910 and 1635 in 1920, its classification being indicated as a town. Its chief support is derived from the Chesapeake and Ohio Railway which employs many of its citizens.

Villages.

Besides the two corporations described above, and in addition to cross-road post-offices containing only one or two families, the following are the most important villages of Summers County, exclusive of Jumping Branch District, with which this Report does not deal, their populations being counted or closely estimated by postmasters or other reliable parties:

Summers County Villages.

Village	Population 1924	Village	Population 1924
Bellepoint (a)	475	Lowell (a)	169
Brooks (e)	34	Marie (a)	40
Claypool (e)	200	Meadow Creek (a)	100
Elton (e)	35	Pence Springs (a)	80
Forest Hill (e), (b)	200	Ramp (e), (b)	250
Greenbrier Springs (a), (c).	35	Sandstone (e), (b)	1000
Green Sulphur Springs (a)	91	Secoma (a)	544
Indian Springs (a)	42	Talcott (e)	600

(a) Actual count; (e) Estimate; (b) Appears to include post-office population; (c) Post-office discontinued.

CHAPTER II.

PHYSIOGRAPHY.

PHYSIOGRAPHIC CHANGES.

EVOLUTION OF MOUNTAIN FORMS

The present land forms of Mercer, Monroe, and Summers Counties are the results of many complex forces that have acted through successive ages of geologic history. The surface rocks consist entirely of stratified layers of sandstone, shale, and limestone, with occasional bands of iron ore along the southern edge, and with deposits of coal in the northwestern parts of Mercer and Summers, there being only insignificant streaks of it in the central belt of the three counties and none along the southern edge. With the exception of coal the strata named were deposited under a considerable depth of water, but the presence of coal, with the invariable attendance of plant remains indicates a flat, swampy condition, the water being shallow enough to permit plant growth but at the same time deep enough to preserve mature vegetation from decay by oxidation. The occurrence of all this stratified material, comprising many thousands of feet in approximately parallel layers, presupposes and requires that there must have been wide areas over which comparatively level conditions prevailed. The present forms show that many changes have taken place since the time of the ancient, subaqueous plains. In a considerable belt along the southern parts of Mercer and Monroe Counties the rocks are no longer horizontal but have been warped into great arches and troughs, or even faulted and completely overturned, by lateral and other forces due to the cooling and readjustment of the

earth's crust. In the central and northern portions of Mercer and Monroe, and in all of Summers County, the rocks are still approximately horizontal, but having a gradual rise southeastward toward the mountains, with only gentle uplifts and depressions which betray the decreasing influence of the forces which formed the mountains.

Full agreement has not yet been reached concerning the force, or forces, by which the uplifts of the Appalachian region, to which the three counties in question belong, have been caused. It is claimed by the exponents of the theory of isostasy, of whom there are many,[1] that anomalies of gravity and the consequent readjustments of density, which tend to preserve the same weight for all equal columns of the earth's mass from its surface to its center regardless of their length, are the primary cause of stratigraphic displacements. Keith,[2] who has intimately studied the Appalachian System for many years, however, points out the utter inadequacy of the isostatic and all other previously advanced theories, to account for the immense overthrusts that exist in these mountains at many localities. He suggests instead, with an assemblage of evidence and logic that appears overwhelming, that the principal lateral movement was caused by batholiths of granitic magma which were extruded in liquid form mainly in Post-Carboniferous time, in the Piedmont belt east of and parallel to the present mountains and which are most noticeable in the localities opposite the greatest overthrusts, and all of which may be connected by subsurface flows into a granitic mass equal in length to the mountain system. On his map of these igneous deposits one of the largest areas shown is in the Carolinas and Georgia, its visible effect in southwestern Virginia and southern West Virginia being not only a diversion of the line of strike from the degree of South 45 West, which generally prevails in northern Virginia, eastern West Virginia, Maryland and New York, to approximately South 75 West, but also a large number of immense

[1]See Bulletin Geological Society of America, Volume 33, pp. 273-410, June, 1922, for recent review of theory by several authors, with reference to many former publications.

[2]Arthur Keith, Outlines of Appalachian Sturcture, Bulletin Geological Society of America, Volume 34, pp. 309-380; June, 1923.

overthrusts which are not nearly so common in the more northern region named. His explanation is herein accepted by the writer as the most probable controlling cause of the overthrust faults of southern West Virginia.

In addition to the great structural changes that have taken place from time to time and that have, in some instances, elevated wide areas of land above the level of the ancient Appalachian Sea, the surface has been eroded and cut into great hollows by the action of rain water, the effect of which began when land first appeared and which still continues at the present time. It is clear, therefore, that two great agencies were concerned in the development of the present mountain forms, the first being the forces of lateral thrust and uplift, whatever they may be, and the second the force of gravity, acting through the medium of erosion, which tends to tear them down.

Previous geologic work by many investigators has shown that the first folding which formed the present Appalachian System, of which the three counties are part, took place at the close of the Permian Period. There are no rocks of this type now left in the area, although they exist in great quantity in the western portion of the State; and there is no evidence to show that they ever did exist in quantity in the three counties. There is a comparatively narrow belt of Pennsylvanian Rocks in the western part of Mercer and Summers Counties but none in the greater portion of these two counties and none in Monroe nor in the counties of Virginia lying southeastward. Campbell[3] surmises that the beds of the Pennsylvanian Period may not have extended far southeast of their present outcrop. If his assumption be true the rocks of the Mississippian Period are the youngest which completely covered the three counties, their presence in such large quantity over most of the area being almost certain evidence that they once extended to the southern limits of Mercer and Monroe where they are now eroded. Assuming that such was the case a restoration of these sediments to the tops of East River Mountain in Mercer, and Peters and

[3]M. R. Campbell, Tazewell Folio, No. 44, United States Geological Survey, 1897.

Potts Mountains in Monroe County, together with all other intervening strata down to the White Medina Sandstone of Silurian age which generally forms their summits, would call for mountain heights of probably 15,000 feet or more above sea-level. Erosive action took place, however, at the same time as the lateral folding and it would be mere conjecture to say what height these mountains actually attained.

The erosive action of mountain streams, begun in the Permian Period, continued through many thousands, or perhaps millions, of years, until at the end of the Triassic Period, as now believed, the Appalachian summits had reached an almost level, or peneplain, condition, sloping gently westward toward the Mississippi Basin and broken only by occasional pinnacles of more resistant rocks.

During the late Jurassic Period lateral forces again became active and raised the peneplain into a second mountain system, exposing still deeper formations of the rock column, which were attacked again by the rains of the Cretaceous Period, bringing them down to a second peneplain.

In the late Cretaceous or early Tertiary Period another series of foldings created a third range of mountains, located in the same region or slightly northwest of the two previous ones, followed by subsequent erosion. A further cycle of uplift took place in late Tertiary time, making a fourth range of mountains, this latter range, or series of ranges, composing the Appalachian System that now exists. The present geologic period being one of erosion the mountains for the fourth time are wearing down to a lower level.[4]

In their geographic relations Mercer, Monroe, and Summers Counties belong mainly in the Cumberland Plateau, or Western Division, of the Appalachian Province, a general description of which may be found in various publications.[5]

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[4]A recent publication by E. W. Shaw, (Ages of Peneplains of the Appalachian Province, Bulletin Geological Society of America, Volume 29, No. 3, September, 1918) disputes the conclusion that any of these peneplains could have been formed at such an early period and still remain in existence over the wide areas they cover, the opinion being expressed that none of them is earlier than Tertiary or perhaps mid-Tertiary time.

[5]See M. R. Campbell, Pocahontas Folio, No. 26, United States Geological Survey; 1896.

A more recent publication by Abbe[6] divides the Appalachian Province into four subdivisions, named from east to west the Blue Ridge, the Great Valley, the Allegheny Ridges, and the Allegheny Plateau. These four subdivisions were named to apply to the physiography of Maryland but the same forms extend into West Virginia and provide a more logical classification of the topography than the older nomenclature, so that they are herein adopted.

Following Abbe's classification all of Summers County and the greater parts of the areas of Mercer and Monroe fall within the boundary of the Allegheny Plateau, but the highly tilted strata of the extreme southern edge of Mercer and of the southern and southeastern portion of Monroe belong to the Allegheny Ridges. The Great Valley and Blue Ridge subdivisions lie farther southeast in Virginia. The Allegheny Plateau region of the three counties consists of an ancient plain sloping gently northwestward, the strata of which are but gently warped and the surface of which has now been cut into innumerable valleys by the erosion of streams leaving sharp or comparatively narrow ridges as remnants of the former plain. In the Allegheny Ridges there has been so much deformation since the time of the Allegheny Plateau that only fragments of its surface remain and these, in extended profile, would conform only to a slight degree with the region farther northwest.

PENEPLAINS.

Schooley Peneplain.

The Schooley Peneplain, named by W. M. Davis from its occurrence on Schooley Mountain, Morris County, New Jersey, is by far the most important and long continued of all the ancient plains of the Appalachian Province, as well as being the earliest of which there is much visible evidence on the northwestern side of the Appalachian Mountain System. Believed by many to have been developed during the

[6]Cleveland Abbe, Jr., Maryland Weather Service, Volume 1, Plate III, opposite page 72; 1899.

Cretaceous Period the statement is made by Abbe[7] that Triassic sediments occur at its type locality while in other regions Jurassic rocks have been deposited on it, indicating that it should be attributed to Jurassic time, in contrast to the earlier belief which appears to have been based on a mistaken correlation. As previously mentioned, page 58, Shaw disputes the idea that this peneplain could have been formed even so early as the Cretaceous Period. Remnants of this great plain, much warped by later folding and often cut into mere ribbons by stream erosion, still exist from the Coastal Plain westward to the Ohio River and beyond.

In Mercer County the Schooley Peneplain appears to be represented by the main ridge of East River Mountain, by Stony Ridge, Blackoak Ridge, Bent Mountain, and farther northwest by Flattop Mountain. Campbell[8] is of the opinion that certain of the highest summits of East River Mountain may have stood as monadnocks above the general surface of this old plain, and it is possible that some of the higher peaks along Flattop may have done likewise.

In Monroe County the Schooley Peneplain is visible in the general summits of Potts, Fork, Peters, Gap, Little, Middle, and Cove Mountains, and in the general plateau surface of Swoopes Knobs and the top of Flattop Mountain and possibly Wolf Creek Mountain (southwest of Alderson). Some of the higher peaks like Nicholson Knob, Elk Knob, and Bickett Knob appear to be remnants of a still earlier plain, although possibly not representing its actual surface.

In Summers County, the Schooley is represented in Wolf Creek Mountain (south of Bellepoint), in Pipestem Knob, and in Whiteoak, Keeney, Chestnut, Big Swell, Red Spring, Fisher, Gwinn, Hump, and Wallowhole Mountains, there being some monadnocks like Keeney Knob, Elk Knob, Stonelick Knob and possibly a few others that clearly rise above its ancient surface.

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[7]Ibid., pp. 120-121.

[8]M. R. Campbell, Pocahontas Folio, No. 26, United States Geological Survey; 1896.

Weverton Peneplain.

The Weverton Peneplain named from Weverton, Washington County, Maryland, and classified by members of the Survey of that State as being of late Jurassic or possibly early Cretaceous age, and having a general elevation of 400 to 500 feet less than the Schooley, appears to be widely represented in the three counties. From Maryland southwestward its presence in Mineral and Grant Counties has been definitely recognized in the Survey Report on that area by the writer. From Grant County southwestward its presence has been mentioned in numerous other Survey Reports by the writer, although it has not been definitely named as the Weverton, being generally described as of late Cretaceous or early Tertiary time in harmony with the views of many previous investigators who appear to have mistaken its age, or who, like the writer has done, have failed to notice the apparently positive evidence secured by the Maryland Survey concerning the age of the Schooley Peneplain. In Tucker County this plain is principally evidenced by the remnants of a base-leveled condition of many minor streams which in their descent from the broad mountain ridges suddenly become revived at elevations that are uniformly 400 to 500 feet below the present Schooley level. In eastern Barbour County it is visible in a broad belt of low topography near Nestorville, Meadowville, and Belington. In central and southern Upshur it is again prominent in a continuation of these lowlands in the vicinity of Buckhannon, Frenchton, and Rock Cave. In Webster County it is recorded by the ancient base-levels of many minor streams in the high mountain areas and by the Cowen Glades where it preceptibly widens. In Nicholas it is quite noticeable in the series of glades which extend southwestward across the county from Camden-on-Gauley by way of Summersville to Keslers Crosslanes. In Fayette County it has been recognized by Hennen,[9] although not named as the Weverton. The evidence in these various counties is so abundant that the correlation of certain low-

[9]Ray V. Hennen, Fayette Report, West Virginia Geological Survey, p. 84; 1919.

lands in the area under study with the Weverton Peneplain appears to be justified.

In Mercer County this old plain is distinctly visible in the plateau lands having elevations of 2400 to 2600 feet above sea-level in the vicinity of Bluefield, Princeton, Athens, Pride, and Lerona, as well as at numerous other points. In Monroe County it appears to be represented by many of the ridge lines of the central and western part, among which may be mentioned Ellison Ridge, Walnut Knob and Wind Creek Mountain. In Summers it is well exhibited in the plateau of Tallery Mountain, in the top of Dempsey Mountain, in the wide shelf which generally follows Keeney Mountain at an elevation of 2500 to 2600 feet, and is also noticeable to a less degree around Big Swell and Hump Mountains, and in the wide meadows around Meadowbridge along the Summers-Fayette County Line.

Harrisburg Peneplain.

The Harrisburg Peneplain, named from Harrisburg, Dauphin County, Pennsylvania, and believed to be of early Tertiary age, since deposits of late Tertiary rocks have been found resting upon it, and having a general elevation of 400 feet less than the Weverton and 900 to 1,000 feet less than the Schooley, has been traced across Maryland and into northeastern West Virginia. In central West Virginia a plain corresponding to it has been noted only at infrequent points but in the territory of this Report there is abundant evidence of an erosion level at the proper interval below the Schooley and Weverton surfaces.

In Mercer County it is principally apparent in the broad meadows of Bluestone River in the vicinity of Spanishburg and in those of Camp Creek near Camp Creek Post-Office, and also in the remnants of old plains near the heads of many minor streams, having an elevation of about 2,000 feet and not yet entirely removed by erosion. In Giles County, Virginia, its apparent surface was noted by Dr. Prouty and the writer at a level of 2135 feet approximately one mile south of Pearisburg, and at 2170 feet two miles west of

Staffordshire. In Monroe County, West Virginia, there is a wide belt of low topography starting with Ballard and recurring again in the rolling limestone lands around Union, Pickaway, Monitor, Sinks Grove, and Johnson Crossroads, all of which comes 800 to 1,000 feet below the apparent surface of the Schooley Peneplain in the plateau of Swoopes Knobs. Farther northeast in Greenbrier County the same wide lowlands are visible at Lewisburg and for many miles farther up the Greenbrier Valley. This great extent of plateau or rolling land, varying from 2,000 to 2,200 feet above sea-level, can scarcely be regarded as an accidental effect of recent local erosion but it can easily be accounted for by the regional base-leveling which took place at the time of the Harrisburg Peneplain.

In southern Summers County the level of the plain is apparent in the vicinity of Neponset, on Saltwell Ridge and Anderson Ridge. Farther north the road between Indian Mills and Buck by way of the head of Johnnycake Fork of Bradshaw Creek closely follows along its level for several miles at an elevation of about 2,100 feet. North of Greenbrier River it is represented by the comparatively flat lands surrounding Clayton and on the road which ascends Keeney Mountain east of Hinton it is visible in a flattened ridge at elevation of 2,005′ B., at the sharp turn of the new road 0.9 mile due east of the mouth of Madam Creek. Other less noticeable occurrences may be found elsewhere in the county.

Somerville Peneplain.

The Somerville Peneplain, so named from its occurrence near Somerville, Somerset County, New Jersey, believed to be of late Tertiary age, and having a general elevation of only about 100 feet less than the Harrisburg, has been traced westward to Cumberland, Maryland, and into Mineral and Grant Counties, West Virginia. Through central West Virginia little attempt has been made to find it. In the territory of this Report flats at the indicated level below the Harrisburg were observed in the vicinity of Cashmere and Cloverdale, Monroe County, but elsewhere are not generally appa-

rent. In southern Summers County there are river pebbles at elevation 1925′ B., along the road 1.2 miles northeast of Shanklins Ferry or 1 mile northwest of Neponset, which would be at the proper level for the Somerville; and at Hinton there is a smoothly rounded point at the upper cemetery along the new road ascending Keeney Mountain 0.8 mile east of the mouth of Madam Creek, at elevation 1900′ B., which is 105 feet below the previously recorded level of the Harrisburg farther up the same road. In Giles County, Virginia, Dr. Prouty and the writer observed river boulders and wash along the road 1.8 miles south of Pearisburg at elevation 2055′ B., on the same road 1.5 miles west of Bane at elevation 2015′ B., and on the Walker Creek road 1.5 miles northeast of White Gate at elevation 2050′ B., all of which belong at about the proper level to correspond with the Somerville Peneplain, provided the correlation of the Harrisburg as above noted for that region is a proper deduction.

RIVER TERRACES.

Evidence of former drainage levels higher than the present channels of New River and its principal tributaries is abundant. The following table gives in condensed form the locations and other data obtained in the field concerning these terrace deposits, starting with New River at the Fayette-Summers County line and passing up into Giles County, Virginia, with those of major affluent streams mentioned in regular order:

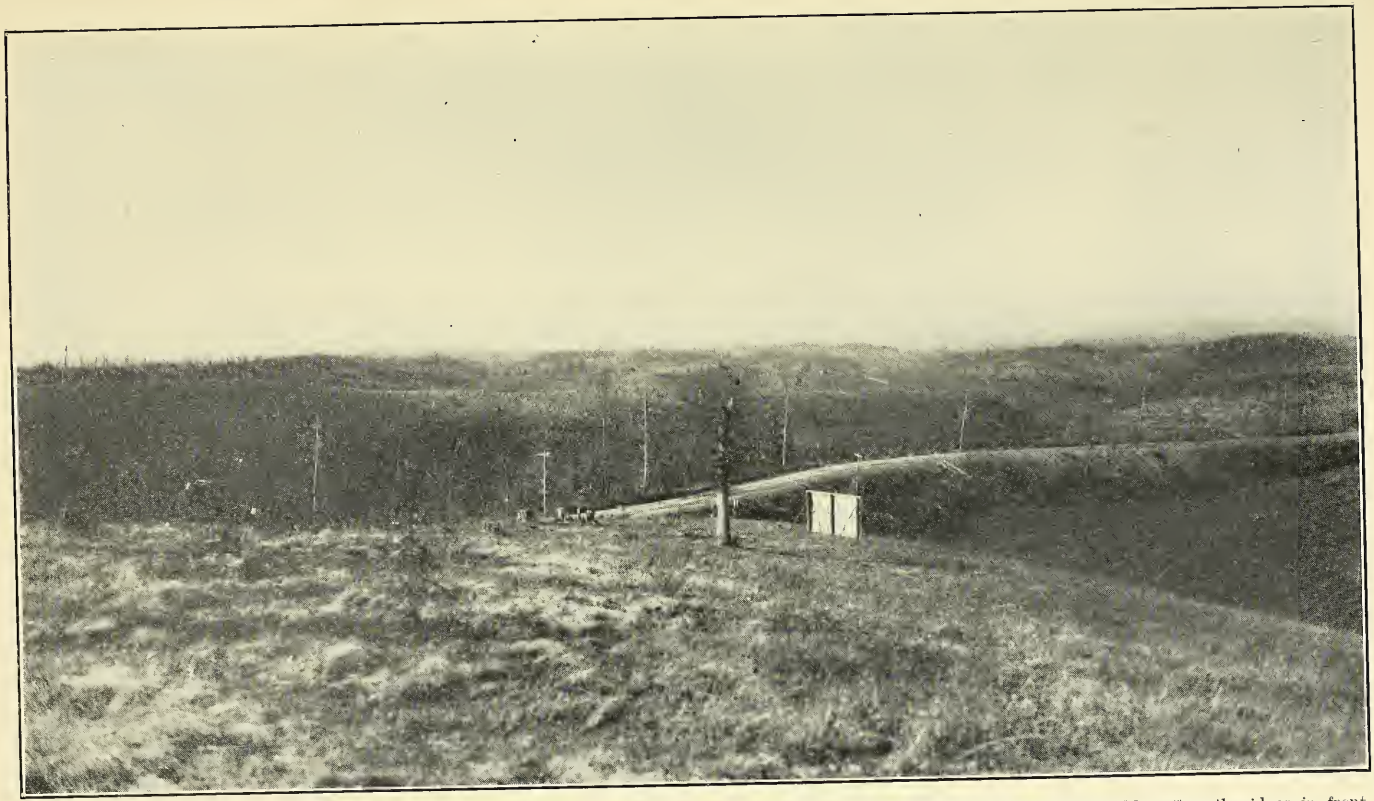

PLATE III.—View from ridge one mile south of Athens, Mercer County, looking northwestward toward Raleigh County coal fields. Smooth ridges in front represent Weverton Peneplain and are made by Hinton Group of Maueh Chunk. Faint ridges in extreme rear are level of Schooley Peneplain, the roeks being Pottsville. (Photo by Palmer & Fowler).

Terrace Deposits along New River and Tributaries.

Stream and Locality	Evidence	Elevation. Top.	Height of top above stream.	Name of Terrace.
New River between Fayette County Line and Mouth of Greenbrier:				
Road 0.4 mile north of Meadow Creek Station (a)	Boulders	1515	265	Fifth
Court-house at Hinton	Flat bench	1465	115	Third
Greenbrier River:				
Browning, opposite	Gravel	1450	60	Second
Wiggins, 0.6 mile southeast of	Gravel	1645	240	Fourth
Hilldale, 0.6 mile west of	Gravel	1645	225	Fourth
Hilldale, 0.5 mile south of	Wide flat	1700	275	Fifth
Hilldale, 0.9 mile south of	Gravel	1795	370	Sixth
Lowell, 0.5 mile southwest of	Clay	1635	165	Third
Lowell, 0.4 mile southeast of	Boulders	1560	90	Second
Lowell, 0.7 mile southeast of	Boulders	1590	120	Third
Lowell, 1 mile east of	Clay	1770	309	Fifth
Lowell, 1.4 miles east of	Clay	1815	345	Fifth
Riffe, 0.3 mile northwest of	Boulders	1645	155	Third
Alderson, 0.6 mile southwest of	Smooth point	1710	180	Third
Alderson, 0.9 mile southwest of	Boulders	1745	215	Fourth
Alderson, 0.5 mile southwest of	Smooth ridges	1765	235	Fourth
Alderson, 0.9 mile northwest of	Boulders	1630	100	Second
New River between Mouth of Greenbrier and Mouth of Bluestone:				
Bellepoint, 0.2 mile southeast of	Boulders and quartz pebbles.	1510	150	Third
Bellepoint, 0.4 mile southeast of	Boulders	1575	215	Fourth
Bellepoint, 0.5 mile southeast of	Boulders	1685	325	Fifth
Bellepoint, 0.6 mile southeast of	Boulders	1880	520	Seventh
Bellepoint, 0.7 mile southeast of	Flat bench	1955	595	Somerville
Bertha, 0.4 mile east of	Boulders	1650	265	Fifth
Bluestone River:				
True, 1.2 miles west of	Boulders	1420	20	First
True, 1.3 miles northwest of	Gravel	1500	100	Second

Terrace Deposits along New River and Tributaries. (Continued.)

Stream and Locality	Evidence	Elevation. Top.	Height of top above stream.	Name of Terrace.
New River between Bluestone and East Rivers:				
Neponset, 1 mile north of...	Boulders	1925	480	Seventh
Wylie Island, 0.3 mile southeast of.....	Clay and boulders	1550	100	Second
Elgood, 1 mile south of....	Single quartzitic boulder, 3 in. diameter	2875	1415	Weverton ?
Glenlyn, 0.9 mile northwest of	Boulders	1700	200	Fourth
Glenlyn, 0.6 mile northwest of	Clay and boulders	1570	70	Second
Glenlyn, at.....	Gravel and sand	1545	45	First
Glenlyn, 0.2 mile southeast of	Clay and boulders	1630	130	Third
Glenlyn, 0.3 mile southeast of	Boulders	1675	175	Third
New River between East River and Walker Creek:				
Peterstown, 0.3 mile north of	Boulders..... clay	1695	170	Third
Peterstown, 0.7 mile southwest of.....	Boulders and clay	1730	205	Fourth
Ripplemead, 1.2 miles west of	Clay	1930	340	Fifth
Ripplemead, 1 mile west of..	Clay	1885	295	Fifth
Ripplemead, 0.8 mile west of	Clay	1815	225	Fourth
Ripplemead, 0.6 mile northwest of.....	Boulders	1805	205	Fourth
Ripplemead, 0.6 mile northwest of.....	Boulders	1785	195	Fourth
Ripplemead, 0.7 mile northeast of.....	Wide flat	1710	120	Third
Pearisburg, 1.2 miles south of	Boulders	1995	405	Sixth
Pearisburg, 1.8 miles south of	Boulders	2055	465	Seventh
Walker Creek:				
Bane, 1.5 miles west of	Boulders	2015	315	Fifth
Staffordsville, 1.8 miles west of	Smooth summit.	2170	445	Sixth
White Gate, 1.5 miles northeast of.....	Boulders	2050	150	Third

(a) Observation by Ray V. Hennen. See Meadow Creek Station Section, Fayette County Report, page 215.

Flood-plain levels, New River: at Bellepoint, 20 feet; at Bertha, 18 feet; at Narrows, 17 feet.

Flood-plain levels, Greenbrier River: at Bellepoint, 20 feet; at Talcott, 17 feet; at Pence Springs, 25 feet.

From the above series of observations there appear to be seven distinct terraces along New River and its major tributaries, which may be summarized in descending order as follows:

Seventh New River Terrace	475	to	525	feet above the rivers
Sixth New River Terrace	400	to	450	feet above the rivers
Fifth New River Terrace	275	to	350	feet above the rivers
Fourth New River Terrace	200	to	250	feet above the rivers
Third New River Terrace	120	to	175	feet above the rivers
Second New River Terrace	75	to	90	feet above the rivers
First New River Terrace	25	to	50	feet above the rivers

In the detailed table of observations the correlation of each observed deposit with its proper place in the succession is indicated. Below the first terrace the low flood-plain of the rivers, coming only 15 to 20 feet above present water-level, occurs; and above the seventh terrace at an interval of 50 to 100 feet the topography of the Somerville Peneplain, smoothly rounded but having no boulders or other river wash, is apparent at various points, while that of the Harrisburg Peneplain with the same absence of alluvium occurs at 150 to 200 feet above the seventh terrace. The absence of river wash above the seventh terrace, in contrast to its comparative abundance at this and all lower levels, leads to the inference that a vast lapse of time must have occurred between the Somerville Peneplain of late Tertiary age and the present visible terraces, since it is reasonable to suppose that ancient terraces of alluvium once existed at the higher topographic levels but that they have been entirely obliterated by long erosion, leaving only rounded points and dissected plateaus as evidence of former base-levels.

The significance of the seven terraces of New River above named may be explained in part, or perhaps altogether, by their comparison with the more extended physiography of the Ohio River Valley, to which New River is tributary through the medium of the Great Kanawha. There is full agreement among geologists that the waters of the Ohio and its tributaries once flowed northward into the Saint Lawrence drainage basin but that in Pleistocene time the formation of an immense glacial ice dam of continental extent across

Pennsylvania, Ohio and other adjoining States impounded the water until a new channel was finally cut southward into the Mississippi Basin. The varying levels of the ice dam are reflected from Beaver County, Pennsylvania, southward along the present downward channel of the Ohio and up its major tributaries in West Virginia and other States by quantities of river wash which accumulated during the intervals of arrested stream deepening.

The terraces of the Ohio River, five in number were studied and described by White,[10] their presence across the entire western front of West Virginia being now well known. The terraces of the Great Kanawha, tributary to the Ohio at Point Pleasant, West Virginia, have been studied by Krebs[11] who records four of the Ohio River terraces in Jackson, Mason, and Putnam Counties, and two of them in Kanawha County. On New River above its junction with the Gauley at Gauley Bridge, Fayette County, where the Great Kanawha is formed, the physiography of Raleigh County has been discussed by Krebs in the Raleigh County Report of the Survey and by Hennen in the Fayette County Report but unfortunately no detailed mention of terraces is made in Raleigh County and only one is noted in the Fayette County Report, the same being in the edge of Summers County near Meadow Creek, as above listed.

In Nicholas County the terraces of Gauley River, five in number, have been studied and described in detail by Reger,[12] their correlation with those of the Ohio in part being suggested.

The following table has now been prepared to indicate the probable correlation of terraces on the four rivers named, based on present knowledge which is admitted to be incomplete because there are no gaps in the series of observations recorded:

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[10]I. C. White, Second Geological Survey of Pennsylvania, Report Q, page 10; 1878.

[11]C. E. Krebs, Jackson, Mason and Putnam Report, West Virginia Geological Survey, pp. 33-34, 1911; and Kanawha Report, pp. 52-54; 1914.

[12]David B. Reger, Nicholas Report, West Virginia Geological Survey, pp. 85-90; 1921.

Correlation of Terraces, Ohio, Great Kanawha, Bauley, and New Rivers.

OHIO RIVER (White)		GREAT KANAWHA RIVER (Krebs)		GAULEY RIVER (Reger)		NEW RIVER (Reger	
Name of Terrace	Height above Stream (Feet)	Name of Terrace	Height above Stream (Feet)	Name of Terrace	Height above Stream (Feet)	Name of Terrace	Height above Stream (Feet)
				Fifth	510-650	Seventh	475-525
				Fourth	435-460	Sixth	400-450
Fifth	280-300			Third	210-315	Fifth	275-350
Fourth	200-220	Fourth	200-250			Fourth	200-250
Third	120-130	Third	120-150			Third	120-175
Second	60-80	Second	60-80	Second	90-100	Second	75-90
First	30-40	First	30-40	First	25-30	First	25-50

In the above table the data on the Great Kanawha has been tabulated by the writer from the texts of Mr. Krebs' Reports on Jackson, Mason and Putnam Counties and Kanawha County. In the former area the four terraces are noted by name but in Kanawha County there are only two levels mentioned without a suggested correlation. One of these comes at 75 to 80 feet above the river and the other 140 to 175 feet above it. The first appears to represent the second Ohio River terrace and the other would belong at the third or fourth level. In all the data the tabulation is so arranged that a correlation of terraces is indicated on each horizontal line across the page. It is thus apparent that the four recognized terraces of the Great Kanawha correspond to the first four of the Ohio River, as has already been mentioned by Mr. Krebs. It appears further that the first and second terraces of Gauley River correlate with the first and second of the Ohio and that the third terrace of Gauley is much the same as the fifth of the Ohio, as has been suggested by the writer in the Nicholas County Report. Along Gauley nothing was found to correspond to the third and fourth Ohio terraces but it now appears probable that these may exist, since

the two missing levels have been found on New River. The fourth and fifth terraces of Gauley clearly belong above the five of the Ohio.

Along New River the missing evidence of other localities appears to be found. Here there are seven terraces, all of which are evidenced by boulders, gravel or other indisputable river wash. Of these the first five clearly correspond to the five Ohio terraces, while the sixth and seventh are the same as the fourth and fifth terraces of Gauley. Along the Ohio it is possible that erosion may have removed all trace of the sixth and seventh terraces or it may be that a further search would find them.

The close harmony of the terraces, as indicated by their tabulated correlation, leads to the belief that a common cause was responsible for them all. Those of the Ohio have been attributed by Dr. White to varying levels of the ice gorge near Beaver, resulting in unequal rates of erosion farther upstream. The present evidence would appear to show that the influence of the ice dam was felt for many hundreds of miles from its actual site, although still water, from this cause, could not have existed at elevations clearly above any probable height of the dam. There must have been, therefore, successive stages when erosion along the lower waters almost totally ceased, followed by other stages when a break or partial destruction of the dam produced fierce currents which rapidly reduced the profile of the Ohio and its tributaries until practical equilibrium and a normal rate of erosion was restored for an interval during which the dam remained intact, only to be followed by other breaks in the dam and other cycles of rapid erosion. The evidence thus appears to indicate that the New River terraces are of Pleistocene age.

PRESENT TOPOGRAPHIC FEATURES.

No general statement that adequately describes the topography of the three counties can be made. In Summers County, in the northwestern half of Mercer, and in a comparatively narrow strip along the western edge of Monroe the present topographic effects are almost wholly ascribable

to stream erosion which has gradually cut into ribbons the ancient surface of the Schooley Peneplain, producing a labyrinth of narrow, V-shaped valleys, the comparative youth of which is indicated by the absence at most points of wide bottoms or stream meanders other than those inherited from a previous epoch. In this region the hillsides are extremely steep and often much furrowed by the recent action of water across the red shales which comprise a considerable part of the rock strata. In some cases the ridges are narrow and sharp due to the competing influence of parallel streams but there are also many localities where portions of the old plain still exist in the form of narrow, elevated plateaus. These ridges vary from 500 to 2,000 feet in height above the streams so that travel across them is difficult, the main highways being largely confined to the valleys or the ridges. The rocks in all this region vary but little from the horizontal.

In the region between Bluestone and East Rivers in Mercer County, and in the central northeast and southwest belt of Monroe, only a few of the major streams have cut deep channels through the surfaces of the Weverton and Harrisburg Peneplains which appear to be the controlling plateau elements. Throughout this region, however, there are occasional high ridges that rise to the level of the Schooley Peneplain in sharp contrast to the comparatively low hills that mostly prevail; and there are also some deep valleys like that of New River which have plowed abnormal channels into the lower strata. The rocks in this area are comparatively level except toward the southern edge where tilting of the Alleghenies begins.

Along the southern edge of Mercer County, starting with Stony Ridge, and in the southern and eastern parts of Monroe the topography suddenly changes to that of the typical Allegheny Mountain type, the ridges being produced by sharp folding of the rock strata while the streams as a rule follow the structural depressions between them. These sharp ridges vary in height from 500 to 1,500 feet above the valleys, but there is great variety in the character of their slopes, some being rough and boulder strewn while others are smooth shale or limestone land.

Hump, Gwinn, and Wallowhole Mountains. — Hump, Gwinn, and Wallowhole Mountains comprise a former continuous ridge across the portion of northern Summers County east of New River and between Meadow and Lick Creeks, their present summits being from 3,200 to 3,300 feet above sea-level or approximately 2,000 feet above New River. Stream erosion has cut deep gaps between them, however, so that they now appear as isolated knobs, crowned by the hard rocks of the Pottsville Series while the alternating sandstones and soft shales of the Mauch Chunk form their main bulk, the strata being almost level.

Fisher and Red Spring Mountains.—Fisher and Red Spring Mountains, lying between the headwaters of Lick Creek and Meadow River in eastern Summers County, may be described in much the same terms as the three above mentioned, being portions of a formerly continuous ridge, and having tops that reach 3,150 and 3,200 feet, respectively, above sea-level, with much the same geologic conditions as mentioned.

Big Swell and Chestnut Mountains.—Big Swell Mountain, lying between Lick and Laurel Creeks, and Chestnut Mountain, between Laurel Creek and New River, are of the same type as all the above described, being crowned by a thin, durable deposit of Pottsville, which preserves from erosion the much less stable Mauch Chunk below. Big Swell Mountain is 3,050 feet above sea-level at its highest point while Chestnut reaches 3,100 feet, being approximately 1,800 feet above New River.

Keeney Mountain.—Keeney Mountain, passing in a northeast and southwest direction across the eastern half of central Summers County is not only the highest land in the county but also approaches closely the elevations reached by the Allegheny ridges of Mercer and Monroe. Its highest points, like Stonelick Knob, Elk Knob, and Keeney Knob, are formed by the hard Pottsville sandstones, the elevation of Keeney Knob being 3,945 feet above sea-level or approximately 2,400 feet above Greenbrier River at the Summers-Monroe County line. A feature of this mountain is the comparatively wide topographic shelf formed by the hard Princeton Conglom-

erate along both its sides at a high elevation above the valleys.

Tallery Mountain.—Tallery Mountain, in southwestern Summers County, southeast of and parallel to Bluestone River, is a high ridge that is mainly formed by the Princeton Conglomerate, there being various monadnocks that rise above this hard rock. Its highest point is Pipestem Knob which is 2,932 feet above sea-level and about 1,400 feet above Bluestone River, or more than 1,500 feet above New River.

Wolf Creek Mountain.—Wolf Creek Mountain, composing part of the angle between New and Greenbrier Rivers and lying mainly parallel to the former, is mainly composed of the comparatively soft Mauch Chunk sediments, its top being mostly preserved from erosion by the Princeton Conglomerate. At the triangulation point south of Low Gap School this mountain reaches a height of 2,850 feet above sea-level, which is slightly less than 1,500 feet above New River.

Bent Mountain.—Bent Mountain, lying in northeastern Mercer County, and being a southward continuation of Tallery Mountain, is a rainbow-shaped ridge rising to a height of 3,073 feet above sea-level, or 500 feet above the plateau formed by the Princeton Conglomerate at Pride, or more than 1,600 feet above New River at Mercers Salt Works. It is formed entirely by flat-lying Mauch Chunk rocks.

Blackoak Mountain.—Blackoak Mountain is a short, anticlinal ridge in southwestern Mercer west of Princeton, its axis being parallel to Bluestone River. It is mainly formed by the hard Stony Gap Sandstone of the Mauch Chunk Series, which is the crest of the arch in this sector of the Abbs Valley Anticline. The ridge reaches a height of 3,250 feet above sea-level, or about 1,000 feet above Bluestone River.

Stony Ridge.—Stony Ridge is a sharp topographic feature in southern Mercer County, approximately 12 miles in length, starting just northwest of Graham, Virginia, and passing northeastward across the West Virginia border and continuing in the same direction north of and approximately parallel to the courses of the branch of Bluestone River

which heads at Bluefield and to that of East River until it is cut in two by Twelvemile Creek in the vicinity of Ingleside. Beyond this creek sections of the same ridge still remain as far northeastward as New River but several transverse streams interrupt the continuous effect. Its greatest height above sea-level is attained at a knob about one mile northeast of Bluefield where it reaches 3,100 feet and is about 550 feet above the level of the city. Its elevation above East River in the vicinity of Ingleside, however, is about 850 feet, due to the greater depth of the stream channel. This ridge is of interest because of its very evident formation by the lateral thrust from the southeast which formed the present Allegheny Mountains, the strata in the ridge, which are of Mississippian age, being pushed beyond a vertical position so that they now incline toward the southeast and their present upper surfaces were formerly the bases. In the crest of the ridge the hard Hinton Sandstone, or quartzite, is a conspicuous feature, making a jagged escarpment at numerous points.

East River Mountain.—East River Mountain, the crest of which forms the entire southern boundary of Mercer County, originates in Tazewell County, Virginia, two or three miles east of Witten Mills, or 15 miles southwest of Bluefield, and extends northeastward without break for 35 miles to the narrows of New River, its approximate bearing being North 70 degrees East. Its height above sea-level varies from 3,200 feet to more than 4,000 feet, the contour at Wilson Triangulation Point, east of Witten Mills, Virginia, being 4,300 feet, while Buckhorn Knob, at the head of Pigeon Creek, 3.2 miles southwest of Oakvale, is 4,020 feet, being the highest peak along the Mercer County line, and being approximately 2,300 feet above the valley of East River. Throughout its extent it has a remarkably uniform crest line without deep gaps, probably because its summit is mainly formed by the White Medina Sandstone of Silurian age which erodes with difficulty. Its present geologic structure is anticlinal, the strata having a dip toward the southeast. On the southeastern, or Virginia, side the slope is mainly formed by the Clinton Series but on the north there are beds

of basal Ordovician or possibly late Cambrian age. Near the northern base the rocks are faulted and overturned so that there was once an immense anticline at some stage of folding prior to the final faulting, making it probable that the crest of the mountain once stood approximately over the present position of the St. Clair Fault. The height of the mountain at that time may only be conjectured, since the uplift may not all have taken place before erosion of the broken beds began.

Peters Mountain.—Peters Mountain, approximately 50 miles in length, starts at the narrows of New River, north of the town of Narrows, Virginia, being a direct continuation of East River Mountain although bearing a different name. From the narrows it extends northeastward with a course approximately North 62 degrees East, forming the principal part of the line between Monroe County, West Virginia, and Giles County, Virginia, but passing entirely into Monroe County at the head of Potts Valley southeast of Zenith, and so continuing for nearly 12 miles. Just southeast of Centennial it becomes the line between Monroe County and Craig County, Virginia, and so remains for seven miles to the southeast corner of the former county, beyond which it passes entirely into Virginia and ends in Alleghany County in the angle formed by the junction of Cast Steel Run with Potts Creek nearly 10 miles from the Monroe County corner. Its elevation above sea-level varies from 3,000 to 4,000 feet, the highest point being a knob two miles south of Zenith, Monroe County, reaching 4,050 feet. Throughout most of its length the top is formed by the hard White Medina Sandstone of Silurian age which preserves the crest line at a high level. Its geologic structure is a continuation of that of East River Mountain above described.

Fork Mountain.—Fork Mountain, originating in Monroe County between the two branches of Potts Creek northwest of Waiteville, extends southwestward into Giles County, Virginia, approximately parallel to Peters Mountain, and ends against a high, transverse buttress known at Butt Mountain, northeast of Ripplemead. At the Monroe-Giles County line the elevation is 3,940 feet above sea-level but farther south-

east in Virginia the old topographic maps show a slightly greater height. Its structure is anticlinal, the slopes being mostly formed by the Clinton Series.

Potts Mountain.—Potts Mountain, which forms the extreme southern line between Monroe County and Craig County, Virginia, for a distance of 13 miles, is part of a continuous range starting in Giles County, Virginia, five miles northeast of Eggleston and extending approximately 37 miles northeastward to Nicholls Knob in Alleghany County, Virginia, near its common corner with Craig and Botetourt. The southwestern end of this mountain in Giles County is known as Salt Pond Mountain, the highest point of the range, Bald Knob, being in this locality, with a height of 4,348 feet above sea-level. Along the southern edge of Monroe County the summit varies from 2,900 to 4,000 feet above sea-level, the latter height at the southwest corner of the county being about 1,800 feet above the level of Waiteville. The structure of that portion of the mountain in, or adjacent to, Monroe County is mainly monoclinal with dips toward the southeast, the crest being formed mostly by the White Medina Sandstone but in part by Clinton or Red Medina rocks. At the northern base the early dolomites of Ordovician age are at some points exposed.

Just to the north of Potts Mountain in Monroe County there is a discontinuous series of sharp ridges named as **Little Mountain** which should not be confused with the more extensive range of that name lying farther north and later described. There ridges are of varying heights, the greatest elevation being at the line between Monroe and Giles Counties where one point is 3,725 feet. This topography is cut by several transverse streams which have obliterated portions of the ridge; and the geologic structure is complicated, the sandstones of the Oriskany, Clinton, and White Medina formations being mainly responsible for the sharp features.

Gap Mountain.—Gap Mountain, lying north of, and approximately parallel to, Peters Mountain in southern Monroe, and being continued farther eastward by **Moss Mountain** which is part of the same uplift, starts just northeast of McGlone and extends northeastward almost to the Virginia State

line northwest of Sweet Springs, its length being nearly 15 miles. At Gap Mills it is cut entirely in two by Second Creek which exposes its structure as monoclinal with a rapid northwestward dip, the slope being mainly formed by the Oriskany and Clinton with exposures of White Medina along the crest. Along the southern slope the strata are overturned and finally broken by the great St. Clair Fault which brings the Beekmantown Limestone of Ordovician age into contact with much younger rocks. This range reaches a height of 3,347 feet above sea-level at High Head Mountain northeast of Centennial, making a relief of more than 1,000 feet above Sweet Springs Creek.

Little Mountain.—Little Mountain starts in the southwestern corner of Monroe County, two or three miles southeast of Peterstown and extends northeastward across the county, its eastern end being known as **Middle Mountain** and its total length being approximately 32 miles. In the vicinity of Peterstown it is less than two miles north of Peters Mountain but the distance between them gradually increases until it is five miles at the eastern edge of the county, the two ranges in that region being separated by Gap Mountain, previously described. Throughout its length it is cut by many transverse, northward-flowing streams so that there is no continuous ridge of more than a few miles length but the same structure is revealed in every locality. The greatest height is attained along Middle Mountain southeast of Wylie Church where the ridge reaches 3,200 feet, being 1,000 above the valley of Back Creek. Its structure is monoclinal, the northern slope being formed mainly by the hard sandstones of the Pocono Series while on the south the Chemung and Portage are found. From the western end of the mountain near Peterstown northeastward as far as Red Mill, however, the rocks are overturned so that the present dip is sharply southward, but northeast of Red Mill their position gradually changes to a normal northwest dip. In its more extended relationship this range is reflected as far southwest as Bluefield where the sharp minor ridge which almost completely separates Bluefield from South Bluefield is a direct continuation of its structure, the same features being evident in many small

knobs between East River and East River Mountain in the region between Bluefield and New River.

Cove Mountain.—Cove Mountain, in eastern Monroe County and northwest of Middle Mountain, is a high symmetrical ridge, six miles long, which reaches its peak in Elk Knob with an elevation of 3,423 feet, or nearly 1,200 feet above the valley of Second Creek. This ridge is monoclinal with sharp southeastward dips, the southern slope being formed by the Pocono Series while the Chemung occurs on the north, a hard conglomerate near the top of this latter series being mainly responsible for the high crest.

Brushy Mountain and **Daniels Ridge,** lying west of Cove Mountain, are mostly formed by Chemung rocks, while **Eads Ridge,** farther west, is mainly Pocono.

Swoopes Knobs.—Swoopes Knobs, lying a few miles west of Union, Monroe County, and covering a few square miles, consist of a high table-land with superimposed monadnocks, the general mass being almost entirely surrounded by much lower ground. The highest point is Bickett Knob at the northern end of the plateau, its elevation being 3,330 feet, or 1,522 feet above the government bench at Salt Sulphur Springs, or approximately 1,650 feet above Second Creek at Hokes Mill. This mountain is a vast pile of Greenbrier and Mauch Chunk Limestones, there being a cap rock of Knobs Sandstone of Mauch Chunk age at the top of the plateau. The structure is gently synclinal, as shown by Map VI.

Flattop Mountain.—Flattop Mountain, in northern Monroe, four or five miles southeast of Alderson, is a short, asymmetrical ridge reaching 3,190 feet above sea-level, or about 1,600 feet above Greenbrier River. Its structure is monoclinal with a fairly rapid dip toward the west, this slope of the mountain, as well as its crest, being formed almost entirely by the Knobs Sandstone of Mauch Chunk age. Its steep eastern slope is mainly composed of Greenbrier Limestone.

Wolf Creek Mountain.—Wolf Creek Mountain, lying in northwestern Monroe southwest of Alderson with its axis extending in a northwest-southeast direction, is a high ridge, approximately six miles long, reaching its crest at 2,765 feet, or approximately 1,250 feet above Greenbrier River. It is mainly

formed by Mauch Chunk sediments, there being a syncline which cuts diagonally across its middle.

Wind Creek Mountain.—Wind Creek Mountain is a short ridge, extending across the Monroe-Summers County line in a northwest and southeast direction, its locality being a few miles southeast of Talcott. Its greatest height is 2,350 feet, or approximately 900 feet above Greenbrier River. Its southern slope is mainly formed by the Knobs Sandstone of Mauch Chunk age, the mountain being crossed almost at right angles to its axis by an anticline that plunges rapidly southward.

DRAINAGE BASINS.

A general view of the drainage system of Mercer County is afforded by Figure 3, of Monroe by Figure 4, and of Summers by Figure 5, all prepared by Mr. Price, and the detailed study of the same may be pursued on Maps I, III, and V which are found in a separate atlas and which reveal the relationships of the drainage to the topography. In the southern portions of Mercer and Monroe Counties, the major streams, with the exception of New River, generally follow parallel to the mountain ranges, while New River and the minor streams have been the principal agencies in cutting across them.

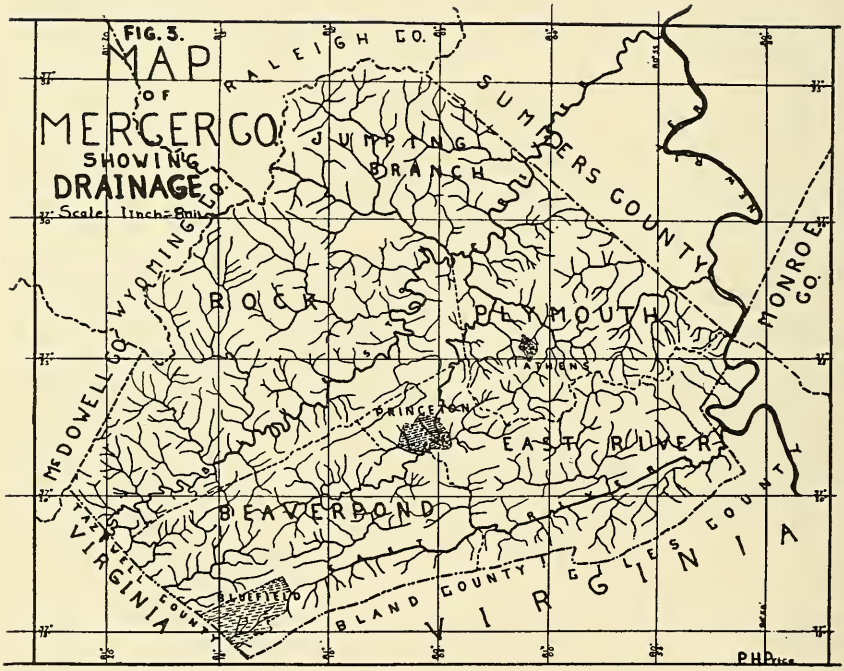


FIG. 3.
MAP
OF
MERCER CO.
SHOWING
DRAINAGE
Scale: 1 inch = 8 mi.
RALEIGH CO.
SUMMERS COUNTY
JUMPING BRANCH
ROCK
PLYMOUTH
MONROE CO.
ATHENS
BRINCEFIELD
EAST RIVER
WYOMING CO.
MCDOWELL CO.
VIRGINIA
BEAVERPOND
BLUEFIELD
BLAND COUNTY
VIRGINIA
PHP

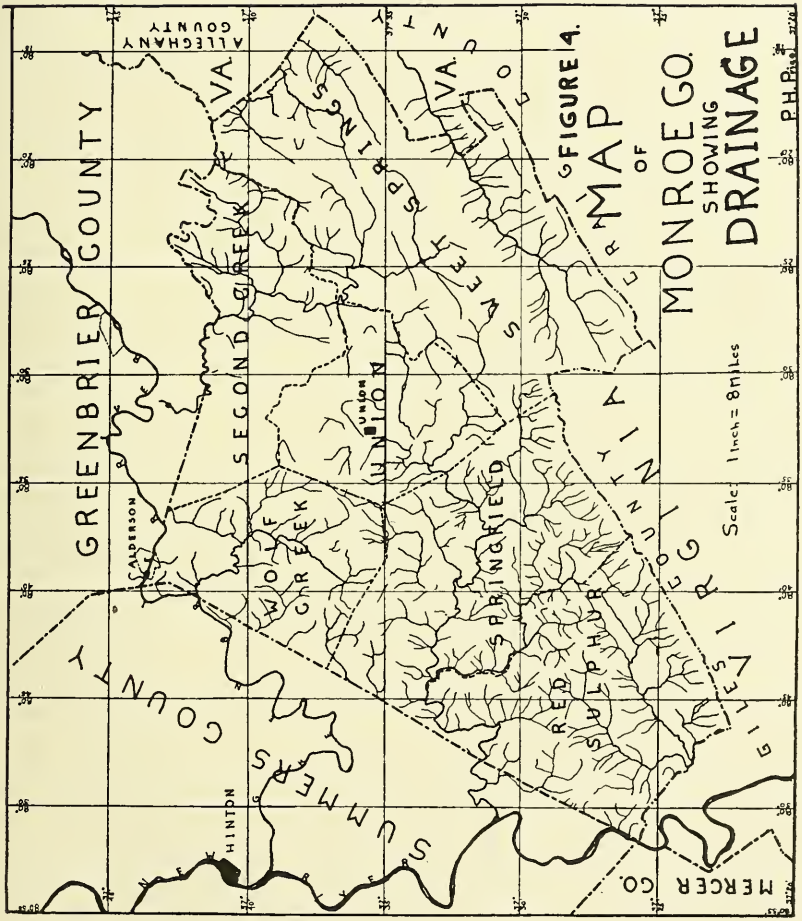


FIGURE 4.
MAP
OF
MONROE CO.
SHOWING
DRAINAGE
P.H.Price
GREENBRIER COUNTY
ALLEGHANY COUNTY
VA.
VA.
SUMMERS COUNTY
MERCER CO.
SECOND CREEK
WOLF CREEK
SPRINGFIELD
RED HOUTH
UNION
CALDERSON
HINTON
SWEET SPRINGS
GOSHEN
GILES
Scale 1 Inch = 8 Miles

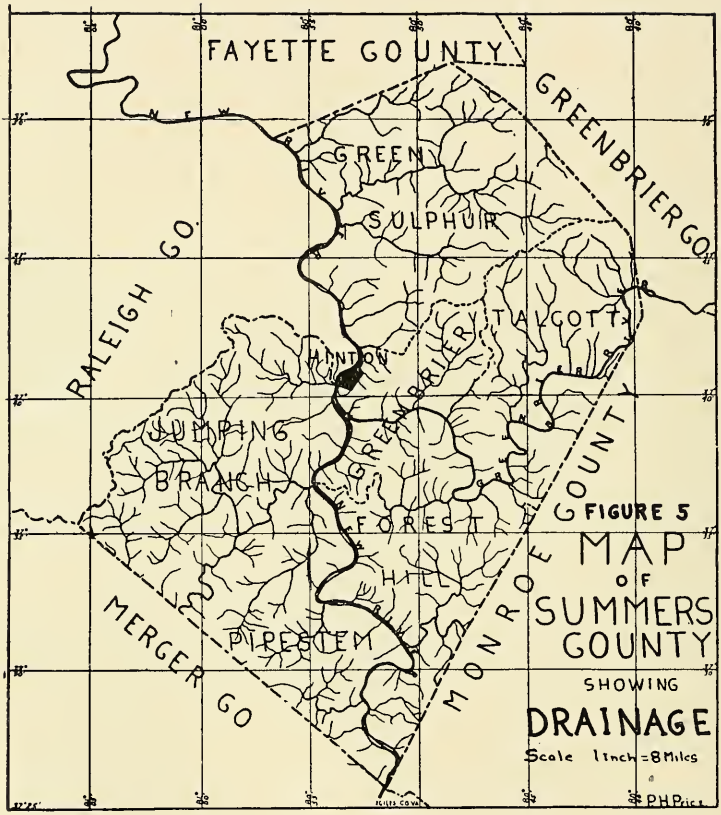


Table of Stream Data.

The following table gives a list of the principal streams of the three counties, the rate of fall and length, both actual stream measurement and air-line distances being determined. The last column shows the ratio between the total distance (T. D.) and the air-line distance (A. L. D.). Those having the greatest ratio are usually streams that have more nearly reached base-level at some period of their history, while others have apparently preserved more direct courses or lost their ancient meanders:

Table of Stream Data.

STREAMS	Total Distance. Miles.	Total Fall. Feet.	Rate of Fall per Mile—Feet.	Air-Line Distance—Miles.	Ratio, T. D. to A. L. D.
New River, source to mouth	321.1	3150	9.81	112.0	2.87
New River, source to Weaversford, N. C.	79.0	1300	16.45	33.0	2.39
New River, Weaversford to Little River (East of Dublin), Va.	99.0	700	7.07	57.5	1.74
New River, Little River to Narrows, Va.	46.0	275	5.98	22.0	2.09
New River, Narrows to Bellepoint, W.Va.	35.7	190	5.60	22.7	1.57
New River, Bellepoint to Meadow Creek.	13.6	105	7.72	11.3	1.20
New River, Meadow Creek to mouth (Gauley Bridge)	47.8	615	12.87	28.4	1.65
Meadow Creek	8.5	1545	181.76	7.8	1.09
Farley Creek	4.4	1440	327.27	3.8	1.16
Lick Creek	12.5	2530	202.40	10.3	1.21
Mill Creek	4.6	1460	317.39	3.9	1.18
Laurel Creek	7.7	1930	250.65	7.5	1.02
Fall Branch	4.6	1400	304.35	2.6	1.77
Kates Branch	2.6	1575	605.77	2.5	1.04
Brooks Branch	3.6	1510	419.44	3.2	1.13
Tug Creek	2.5	1600	640.00	2.1	1.19
Madam Creek	6.0	1400	233.33	5.3	1.13
Beech Run	3.0	800	266.67	2.8	1.07
Greenbrier River, source to mouth	142.0	2340	16.48	96.0	1.48
Greenbrier River, source to Marlinton	44.0	1550	35.23	40.0	1.10
Greenbrier River, Marlinton to Second Creek	60.0	540	9.00	41.0	1.46
Greenbrier River, Second Creek to mouth	38.0	250	6.58	20.7	1.84
Big Creek	5.2	1600	307.69	4.9	1.06
Powley Creek	2.0	590	295.00	1.9	1.05
Wolf Creek (Wolf Creek District)	4.7	760	161.70	3.3	1.39
Little Stony Creek	4.5	600	133.33	3.6	1.25
Stony Creek	5.4	550	101.85	4.6	1.17
Hungard Creek	9.3	1935	208.06	7.0	1.33
Wind Creek	4.0	530	132.50	3.5	1.14
Kelly Creek	5.8	525	90.52	4.1	1.41
Wolf Creek (Wolf Creek District)	11.7	900	76.92	7.5	1.56
Laurel Creek	4.4	675	155.68	3.8	1.16
Broad Run	4.5	1075	238.89	3.6	1.25
Griffith Creek	4.1	1735	423.20	3.9	1.05
Muddy Creek	19.7	765	38.84	12.0	1.64
Second Creek, source to mouth	26.0	1035	39.81	14.0	1.85
Second Creek, source to Gap Mills	5.2	325	62.50	4.7	1.11
Second Creek, Gap Mills to Second Creek village	11.6	450	38.79	7.5	1.54
Second Creek, Second Creek village to mouth	9.2	260	28.26	5.7	1.61
Rayburn Draft	3.6	675	187.50	3.5	1.03

Table of Stream Data.—(Continued.)

STREAMS	Total Distance. Miles	Total Fall. Feet.	Rate of Fall per Mile—Feet.	Air Line Distance—Miles.	Ratio, T. D. to A. L. D.
Carpenter Creek	4.3	725	168.60	4.1	1.04
Laurel Creek	8.7	900	103.45	6.6	1.32
Forest Run	3.5	600	171.43	3.0	1.17
Devil Creek	3.8	210	55.26	3.6	1.05
Back Creek	3.0	225	75.00	2.9	1.04
Kitchen Creek	5.2	325	62.50	4.7	1.11
Leatherwood Creek	1.8	880	488.89	1.6	1.12
Bluestone River, source to mouth	77.2	2125	27.53	45.0	1.71
Bluestone River, source to Graham, Va.	13.5	1135	84.00	9.8	1.37
Bluestone River, Graham to Bluestone	8.4	115	13.69	5.0	1.68
Bluestone River, Bluestone to Brush Creek	36.8	470	12.77	19.5	1.88
Bluestone River, Brush Creek to mouth	18.5	415	22.43	12.2	1.51
Pipestem Creek	8.2	1125	137.32	7.1	1.15
Little Bluestone River	8.8	1610	182.95	5.4	1.63
Mountain Creek	8.0	1650	206.25	6.1	1.31
Laurel Creek	3.2	840	262.50	2.9	1.10
Indian Branch	3.7	760	205.41	3.5	1.05
Whiteoak Creek	2.3	740	321.74	2.0	1.15
Brush Creek, source of South Fork to mouth	24.0	810	33.75	15.3	1.56
Laurel Creek	6.5	410	63.08	4.7	1.38
Christian Fork	4.2	175	41.67	3.9	1.08
Glady Fork	2.8	270	96.43	2.6	1.08
North Fork	5.0	185	37.00	4.0	1.25
South Fork	6.3	235	39.30	4.5	1.40
Camp Creek	12.3	1200	97.56	8.2	1.50
Wolf Creek	4.0	635	158.50	3.2	1.25
Rich Creek	9.8	1100	112.24	7.6	1.29
Blacklick Creek	7.0	630	90.00	5.5	1.27
Widemouth Creek	12.2	840	68.85	9.0	1.35
Sandlick Creek	2.7	580	214.81	2.2	1.23
Crane Creek	6.6	1050	154.55	5.2	1.27
Lorton Lick Creek	4.5	450	100.00	3.2	1.41
Flipping Creek	4.2	400	95.24	3.8	1.11
Simmons Creek	3.2	315	98.43	3.0	1.07
Mill Creek	2.0	400	200.00	1.8	1.11
Laurel Fork	11.8	550	46.61	9.0	1.71
Lick Branch	2.0	370	185.00	1.7	1.18
Mud Fork	13.0	700	53.85	12.0	1.09
Brushy Fork	6.7	450	67.16	5.6	1.19
Beaver Pond Creek	4.8	275	57.29	3.8	1.27
Toms Run	4.3	1000	232.56	2.8	1.54
Buffalo Creek	1.5	600	400.00	1.3	1.15
Indian Creek, source to mouth	34.0	765	22.50	19.0	1.78

Table of Stream Data.—(Continued.)

STREAMS	Total Distance. Miles.	Total Fall. Feet.	Rate of Fall per Mile—Feet.	Air Line Distance—Miles.	Ratio, T. D. to A. L. D.
Indian Creek, source to Greenville	18.0	600	33.33	10.0	1.80
Indian Creek, Greenville to mouth	16.0	165	10.31	8.9	1.79
Bradshaw Creek	5.0	550	110.00	4.4	1.14
Stinking Lick Creek	5.2	500	96.15	4.2	1.24
Hands Creek	13.8	1000	72.46	10.0	1.38
Blue Lick Creek	4.1	400	97.56	3.3	1.24
Indian Draft	4.6	900	195.65	3.0	1.53
Cooks Run	2.8	160	57.14	2.0	1.40
Laurel Creek, source to disappearance	7.7	1325	172.08	6.2	1.24
Back Creek	5.3	900	150.94	4.6	1.15
Rock Camp Creek	5.5	1300	236.36	4.5	1.22
Dropping Lick Creek	7.1	750	105.63	6.7	1.06
Turkey Creek	8.5	1000	117.65	7.5	1.13
Burnside Creek	7.6	875	115.13	6.5	1.17
Taggard Branch	6.3	630	100.00	5.5	1.14
Lick Creek	7.8	1165	149.36	6.6	1.18
Dry Fork	3.8	900	236.84	2.7	1.41
Hackett Creek	2.6	570	219.23	2.4	1.08
Ovenlick Creek	2.6	770	296.15	2.4	1.08
Crooked Run	3.0	660	220.00	2.5	1.20
Island Creek	7.1	1060	149.30	5.7	1.25
Stony Run	2.5	840	336.00	2.3	1.09
Little Island Creek	3.7	950	262.43	3.3	1.12
Roundbottom Creek	2.4	800	333.33	1.8	1.33
Cooper Branch	3.2	900	281.25	3.0	1.07
Smith Branch	2.5	750	300.00	2.2	1.14
Adair Run	4.5	1200	266.67	3.8	1.18
East River	23.0	1040	45.22	21.3	1.08
Big Spring Branch	4.2	900	214.29	3.8	1.11
Pigeon Creek	2.8	1050	375.00	2.4	1.17
Fivemile Creek	5.6	950	169.64	4.8	1.17
Hales Branch	2.6	700	269.23	2.4	1.08
Payne Branch	5.8	875	150.86	4.0	1.45
Twelvemile Creek	4.0	650	162.50	3.0	1.33
Rich Creek	11.0	1000	90.91	8.6	1.28
Brush Creek	8.6	500	58.14	7.0	1.43
Scott Branch	2.0	900	450.00	1.8	1.11
Crooked Creek	3.5	700	200.00	2.6	1.35
Mud Run	2.6	225	86.54	2.5	1.04
Dry Creek	5.0	900	180.00	3.9	1.28
Jackson River (of James) drainage as follows:					
Cove Creek, source to mouth	8.2	750	91.46	6.4	1.28
Back Creek	6.0	575	95.83	5.4	1.11
Sweet Springs Creek, source to mouth	9.2	850	92.39	8.2	1.12

Table of Stream Data.—(Concluded.)

STREAMS	Total Distance. Miles.	Total Fall. Feet.	Rate of Fall per Mile—Feet.	Air Line Distance—Miles.	Ratio, T. D. to A. L. D.
Sweet Springs Creek, source to Virginia line	6.2	675	108.87	5.8	1.07
Potts Creek, source of South Fork to mouth	42.0	1500	35.71	36.0	1.17
Potts Creek, source of South Fork to Paint Bank, Va	16.5	950	57.58	15.7	1.05
Ewin Run	3.5	975	278.57	3.0	1.07
Trout Branch	2.8	825	294.64	2.2	1.27
North Fork	5.0	1110	222.00	4.8	1.04
South Fork	5.8	660	113.79	5.5	1.05
Crosier Branch	3.0	1000	333.33	2.3	1.30

Areas of Drainage Basins.

The following table, prepared by the writer, gives a planimetric determination of the areas of the principal drainage basins of the three counties, the joint topographic sheets of the United States and West Virginia Geological Surveys being used for authority:

Areas of Drainage Basins.

STREAMS	Square Miles
New River, entire	6981.00
New River, above Meadow Creek	6559.00
New River, above East River	3787.00
Meadow Creek, entire	29.01
Beelick Branch	4.87
Coon Creek	4.18
Lefthand Creek	6.84
Farley Creek	6.90
Lick Creek, entire	39.09
Mill Creek, entire	9.60
Fish Creek	4.23
Red Spring Branch	6.06
Laurel Creek	18.23
Fall Branch	8.04
Kates Branch	2.39

Areas of Drainage Basins.—(Continued.)

STREAMS	Square Miles
Brooks Branch	4.94
Tug Creek	3.06
Madam Creek, entire	12.69
Righthand Fork	2.95
Beech Run	3.70
Greenbrier River, entire	1629.43
Big Creek	10.83
Powley Creek	2.28
Howard Creek	2.19
Wolf Creek	11.40
Spruce Run	2.30
Kissinger Run	2.02
Little Stony Creek	4.88
Stony Creek	6.74
Hungard Creek, entire	18.35
Boone Creek	3.44
Righthand Fork	6.00
Wind Creek	3.55
Kelly Creek	7.41
Wolf Creek, entire	38.70
Laurel Creek	7.63
Broad Run	6.66
Griffith Creek	6.26
Muddy Creek	116.41
Second Creek, entire	116.34
Rayburn Draft	3.70
Carpenter Creek	6.58
Laurel Creek	17.66
Forest Run	3.57
Devil Creek, entire	10.24
Little Devil Creek	3.30
Dry Run	1.62
Back Creek	8.89
Kitchen Creek	10.37
Leatherwood Creek	1.45
Bluestone River, entire	463.54
Pipestem Creek	13.70
Surveyor Branch	3.66
Little Bluestone River, entire	34.85
Suck Creek	7.18
Sunrise Branch	2.18
Parker Creek, entire	10.76
Jumping Branch	6.23
Whiteoak Branch	2.43
Spicelick Creek	2.56
Mountain Creek, entire	22.64
Dust Creek	2.30
North Fork	17.80
Coal Branch	2.78
Laurel Creek	3.52
Indian Branch	5.56
Whiteoak Creek	2.12

Areas of Drainage Basins.—(Continued.)

STREAMS	Square Miles
Brush Creek, entire	74.49
Laurel Creek, entire	16.92
Trace Fork	3.34
Little Laurel Creek	2.31
Beaver Branch	2.36
Christian Fork, entire	6.83
Daves Fork	2.04
Glady Fork	3.16
North Fork	10.64
South Fork, entire	10.65
Middle Fork	2.50
Camp Creek, entire	41.27
Trace Creek	2.60
Mash Fork, entire	13.60
Lefthand Fork	3.70
Bear Creek	2.64
Mill Branch	3.02
Wolf Creek	5.76
Rich Creek, entire	22.51
Pocosin Fork	5.81
Blacklick Creek	8.72
Lashmeet Branch	3.01
Middleton Fork	3.15
Widemouth Creek, entire	25.46
Righthand Fork	11.23
Lefthand Fork	5.63
Sandlick Creek	3.06
Crane Creek	12.31
Larton Lick Creek	4.80
Flipping Creek	4.17
Simmons Creek	4.02
Mill Creek	2.06
Laurel Fork	26.66
Lick Branch	1.72
Big Branch	1.49
Mud Fork	20.24
Brushy Fork	11.18
Beaver Pond Creek	9.36
Toms Run	8.42
Buffalo Creek	1.61
Indian Creek, entire	194.17
Bradshaw Creek, entire	12.49
Johnnycake Fork	4.67
Stinking Lick Creek	9.69
Fitz Run	5.15
Lowell Branch	1.50
Hands Creek, entire	30.36
Blue Lick Creek	6.00
Lick Run	2.52
Symmes Branch	1.71
Indian Draft	4.55
Cooks Run	2.60
Laurel Creek, entire, above disappearance	9.35

Areas of Drainage Basins.—(Concluded.)

STREAMS	Square Miles
Sarton Branch	2.46
Back Creek	5.42
Rock Camp Creek, entire	23.19
Dropping Lick Creek	13.05
Humphreys Run	1.93
Turkey Creek	15.89
Pepper Run	1.30
Burnside Branch, entire	17.23
Taggard Branch	7.40
Cedar Branch	1.59
Lick Creek, entire	21.46
Dry Fork	4.10
Hackett Creek	1.50
Crooked Run	2.60
Island Creek, entire	13.62
Stony Run	1.41
Little Island Creek	3.71
Roundbottom Creek	3.05
Cooper Branch	2.89
Smith Branch	1.80
Adair Run	7.07
East River, entire	77.31
East River, above Fivemile Creek	37.20
East River, above Twelvemile Creek	17.58
Big Spring Branch	6.47
Pigeon Creek	5.32
Fivemile Creek, entire	21.40
Hales Branch	3.83
Payne Branch	9.61
Harmon Branch	1.76
Twelvemile Creek	8.05
Rich Creek, entire	52.80
Brush Creek, entire	17.08
Crooked Run	2.45
Scott Branch, entire	7.66
Trigger Run	3.45
Crooked Creek	6.04
Mud Run	2.31
Dry Creek	6.42
Jackson River (of James) drainage as follows:	
Cove Creek, entire	26.38
Cove Creek, above Back Creek	12.36
Back Creek	8.02
Sweet Springs Creek, entire	18.70
Sweet Springs Creek, above Virginia line	12.52
Potts Creek, entire	174.65
Potts Creek, above Paint Bank Branch	55.54
Ewin Run	4.46
Trout Branch	3.26
North Fork	8.27
South Fork, entire	11.54
Ray Fork	1.03
Crosier Branch	2.35

DESCRIPTION OF DRAINAGE BASINS.

New River.

New River, which with its tributaries drains all of Summers County with the exception of a few square miles that goes into Meadow River, all of Mercer County, and all of Monroe County with the exception of a limited area in the southeastern corner that is a part of the James River drainage basin, rises in the Blue Ridge Mountains of Watauga County, North Carolina, flows generally northward across North Carolina, Virginia, and West Virginia and joins with Gauley River in Fayette County of the latter State to form the Great Kanawha River. The elevation at its source is 3,800 feet and at its mouth 650 feet, making a total fall of 3,150 feet in the 321 miles of its length, or at the rate of 9.81 feet per mile. From its source to the West Virginia line it has cut an immense channel across many high mountain ranges of the Appalachian System, the gap between East River Mountain and Peters Mountain along the State line being the last of these spectacular features. It enters West Virginia at the common corner of Mercer, Summers, Monroe, and Giles Counties and thence flows across Summers County through a deep valley which has been eroded for 1,500 to 2,000 feet below the level of the ancient Schooley Peneplain. Its current across this county is only moderately swift, there being stretches of quiet water broken by numerous rapids and occasional low cataracts among which latter Wylie Falls, Bull Falls, and Sandstone Falls are the most conspicuous. North of the Summers County line, however, the channel becomes exceedingly rough and so remains for most of the way to its junction with Gauley.

The area of its entire drainage basin is 6,981 square miles, the figure for the portion above Meadow Creek, Summers County, being 6,559 square miles, and of that above East River 3,787 square miles.

Throughout its length there are numerous entrenched meanders which are evidence of a former base-leveled condition during a period of peneplanation. Its present cycle, ow-

ever, is one of comparative youth, its general current being rapid while the valley walls are high and steep and the bottoms are usually narrow.

Its principal tributaries in the territory of this Report, in ascending order, are Meadow, Farley, Lick, and Laurel Creeks, Fall, Kates, and Brooks Branches, Madam Creek, Beech Run, Greenbrier River, Leatherwood Creek, Bluestone River, Toms Run, Buffalo, Indian, and Lick Creeks, Crooked Run, Island and Roundbottom Creeks, Cooper and Smith Branches, Adair Run, East River, and Rich Creek.

Apparently the only gaging station established along New River within the territory of this Report is that which the United States Weather Bureau has maintained at Hinton. Also at Fayette, in Fayette County, the United States Geological Survey has maintained a station for many years, the records of which, as assembled from various Water-Supply Papers, have been published in the Fayette County Report of the Survey (pages 44-66, inclusive).

Meadow Creek.—Meadow Creek, which enters New River from the east at Meadow Creek Station, Summers County, rises in southeastern Fayette County near the Greenbrier line and flows southwestward through Fayette and Summers, its total length being 8.5 miles and the area of its drainage basin 29.01 square miles.

Farley Creek.—Farley Creek, tributary to New River from the west, rises near Bragg School, Raleigh County, flows eastward and empties 1.4 miles below New Richmond, its length being 4.4 miles and the area of its drainage basin 6.9 square miles.

Lick Creek.—Lick Creek, tributary to New River from the east, rises in eastern Summers County near the base of Keeney Knob, flows generally westward and empties at New Richmond, its total length being 12.5 miles and the area of its drainage basin 39.09 square miles. Its principal tributaries are Mill Creek and Red Spring Branch.

Laurel Creek.—Laurel Creek rises on the north slope of Keeney Mountain near Ballengee Knob, flows northwestward and empties into New River at Sandstone, its total length be-

ing 7.7 miles and the area of its drainage basin 18.23 square miles.

Fall Branch.—Fall Branch heads against Irish Mountain in Raleigh County, flows southward and then eastward and empties into New River 2.5 miles above Sandstone. Its length is 4.6 miles and the area of its drainage basin 8.04 square miles.

Kates Branch.—Kates Branch, an eastern tributary, rises against Chestnut Mountain, flows southwestward and enters New River at Brooks, the total length being 2.6 miles and the drainage area 2.39 square miles.

Brooks Branch.—Brooks Branch, tributary to New River from the east rises in the angle between Chestnut and Keeney Mountains, flows southwestward and empties at Barksdale, its total length being 3.6 miles and the area of its drainage basin 4.94 square miles.

Tug Creek.—Tug Creek rises on the northern slope of Keeney Mountain, flows southwestward and empties into New River 1.2 miles above Barksdale, its length being 2.5 miles and the area of its drainage basin 3.06 square miles.

Madam Creek.—Madam Creek, tributary to New River from the west, rises against Whiteoak Mountain east of Pluto, Raleigh County, flows southeastward and eastward and empties at Brooklin, opposite Hinton. The total length is 6.0 miles and the area of its drainage basin 12.69 square miles.

Beech Run.—Beech Run, entering New River from the west, heads against Bluestone Mountain, flows northwestward and empties 0.8 mile above Hinton, its total length being 3.0 miles and the area of its drainage basin 3.70 square miles.

Greenbrier River.—Greenbrier River, tributary to New River from the east at Bellepoint, will be described with its tributaries under a subsequent heading.

Leatherwood Creek.—Leatherwood Creek, coming into New River from the west, heads against Cave Ridge, flows eastward and empties 1.2 miles above Bellepoint, its total length being 1.8 miles and the area of its drainage basin 1.45 square miles.

Bluestone River.—Bluestone River, tributary to New River from the west near True, will be described with its tributaries under a subsequent heading.

Toms Run.—Toms Run, entering New River from the west, heads near Pipestem Knob in southern Summers County, flows northeastward and empties at Warford, its basin being fan-shaped. Its total length is 4.3 miles and the area of its drainage basin is 8.42 square miles.

Buffalo Creek.—Buffalo Creek, which is a short, fan-shaped tributary from the east, heads against the southern end of Wolf Creek Mountain, flows southwestward and empties into New River 1.2 miles above Warford, its total length being 1.5 miles and the area of its drainage basin 1.61 square miles.

Indian Creek.—Indian Creek, tributary to New River from the east, apparently heads in the limestone sinks of Monroe County between Pickaway and Bickett Knob, the direction of its submerged or intermittent flow being southward for about four miles to the mouth of Taggard Branch in the vicinity of Salt Sulphur Springs where its flow comes permanently above the surface and turns southwestward. At Raines Corner, five or six miles farther on, its general direction becomes westward and just southwest of Junta in the edge of Summers County it empties into New River. Its total length from source to mouth, including the wide, entrenched meanders of its lower course, is 34.0 miles, and the area of its drainage basin is 194.17 square miles. Its principal tributaries, in ascending order are Bradshaw and Stinking Lick Creeks, Fitz Run, Hands Creek, Indian Draft, Cooks Run, Laurel, Back, Rock Camp, and Turkey Creeks, and Burnside Branch. Some of the upper streams are intermittent or submerged in character, a peculiarity of Laurel Creek being that it goes into a cavern 1.5 miles northeast of Greenville but apparently continues in much the same direction beneath its former channel and comes to the surface again in a large spring just west of Greenville where its waters reach Indian Creek. The lengths and areas of all these tributaries may be found in previous tables.

Lick Creek.—Lick Creek, tributary to New River from the west, heads in the angle between Bent Mountain and Browns Ridge in Mercer County, flows eastward and empties at Mercers Salt Works, its total length being 7.8 miles and the area of its drainage basin 21.46 square miles. Its principal tributaries, in ascending order, are Dry Fork, Hackett Creek and Ovenlick Creek.

Crooked Run.—Crooked Run, entering New River from the east, heads on the plateau in the edge of Monroe County near Chestnut Hill, flows westward and empties at Shanklins Ferry in Summers County, its total length being 3.0 miles and the area of its drainage basin 2.6 square miles.

Island Creek.—Island Creek, coming into New River from the west, heads near Elgood, Mercer County, flows northeastward and empties in Summers County 0.9 mile above Shanklins Ferry, its total length being 7.1 miles and the area of its drainage basin 13.62 square miles. Its principal tributaries are Stony Run and Little Island Creek.

Roundbottom Creek.—Roundbottom Creek, tributary to New River from the west, heads in Mercer County about two miles northwest of Wylie Falls, flows generally eastward and empties at the common corner of Mercer, Monroe, Summers, and Giles Counties, its total length being 2.4 miles and the area of its drainage basin 3.05 square miles.

Cooper Branch.—Cooper Branch, coming into New River from the west, heads in Mercer County two miles northeast of Elgood, flows southeastward into Giles County, Virginia, and empties two miles (air-line measure) below Glenlyn. Its total length is 3.2 miles and the area of its drainage basin 2.89 square miles.

Smith Branch.—Smith Branch, entering New River from the west, rises in Mercer County 1.8 miles northeast of Elgood, flows southeastward into Giles County, Virginia, and empties 1.3 miles due north of Glenlyn, its total length being 2.5 miles and the area of its drainage basin 1.8 square miles.

Adair Run.—Adair Run, tributary to New River from the west, heads in Mercer County just northeast of Elgood, flows southeastward for more than three miles and thence northeastward, crossing the Giles County line near its mouth

and finally empties 0.3 mile north of Glenlyn. Its total length is 4.5 miles and the area of its drainage basin 7.07 square miles.

East River.—East River, tributary to New River from the west at Glenlyn, Virginia, but having most of its course in Mercer County, will be later described under a separate heading.

Rich Creek.—Rich Creek, coming into New River from the east, rises in Monroe County along the northern slope of Peters Mountain, flows northward to Lindside and then generally southwestward to Peterstown where it turns northwestward and for about 1¼ miles becomes the line between Monroe County and Giles County, Virginia, then turns southwestward through the latter county and empties at Rich Creek Station. Its total length is 11 miles and the area of its drainage basin 52.8 square miles, its total fall being 1,000 feet, making an average of 90.91 feet per mile. Its principal tributaries, in ascending order, are Brush Creek, Scott Branch, Crooked Creek, Mud Run and Dry Creek, data on all of which are afforded in the table of Stream Data, page 85, and in the Areas of Drainage Basins, page 89.

Greenbrier River.

Greenbrier River, tributary to New River from the east at Bellepoint, Summers County, 1½ miles south of Hinton, rises in Randolph County east of Shavers Mountain and east of Wildell, and flowing generally southwestward across Pocahontas and Greenbrier Counties, forms a portion of the line between the latter county and Monroe in the vicinity of Alderson, where it passes into Summers County, and finally empties as above stated. The elevation at its source is 3,700 feet and at its mouth 1,360 feet, making a total fall of 2,340 feet in the 142 miles of its length, or at the rate of 16.48 feet per mile. From its source to Marlinton the rate of fall is 35.23 feet per mile, there being but few meanders. From Marlinton to Second Creek the rate of fall is 9 feet per mile, and from Second Creek to Bellepoint only 6.58 feet per mile, there being numerous wide meanders of evidently ancient origin in these latter two sections of its course, since they are strongly

entrenched and the present current is moderately swift and the valley narrow. Its present bed is from 1,000 to 1,500 feet below the level of the ridges, the former figure being the rule in the topography south of the river and the latter north of it where erosion has been less rapid. Its depth below the old plain is almost entirely due to the cutting action of the river, since its course, with minor exceptions, is with the strike of the rocks along the great monocline which generally rises southeastward from the coal fields of the State toward the Allegheny Ridges. Just east of Alderson, however, it cuts through the plateau made by the southern end of the Muddy Creek Mountain, forming a water-gap of some prominence.

The area of its entire drainage basin is 1629.43 square miles, there being a very considerable area of partly virgin and partly cut-over forest land east of the Monroe County line, while farther west the wooded tracts are less extensive.

Its principal tributaries in or touching the territory of this Report, in ascending order, are Big, Powley, Howard, and Wolf Creeks, Spruce and Kissinger Runs, Little Stony, Stony, Hungard, Wind, Kelly, Wolf, Muddy, and Second Creeks.

A gaging station was established at Alderson August 1, 1895, by C. C. Babb and D. C. Humphreys, of the United States Geological Survey, and since that date until the present time, with few interruptions, the gage has been read daily by local observers, Mr. W. J. Hancock being accredited with most of this detail, and discharge measurements have been made from time to time by government officials, the work having been done partly in cooperation with the West Virginia Geological Survey. The gage established in 1895 remained in use until 1903 when a new one was installed. The original description of this station, together with gaging record from August 1 to December 31, 1895, is published in United States Geological Survey Bulletin No. 140, pages 77-78; and the records from January 1, 1896, to September 30, 1918, inclusive, may be consulted in the following Water-Supply Papers of the same organization:

1896, No. 11, page 41.
1897, No. 15, page 571.
1898, No. 27, page 61.

PLATE IV.—View from low ridge east of Union looking west at Union (in middle) and Swoopes Knobs (in background), with Bickett Knob at extreme right. Foreground is outcrop of weathered Greenbrier, which continues through Union and across submerged drainage valley in rear and nearly to top of Swoopes Knobs. Top of Knobs in rear of Union made mostly by Droop Sandstone but this overshoots Bickett Knob which is covered by Reynolds Limestone. (Photo. by Palmer & Fowler).

1899, No. 36, pages 163-164.
1899-1900, No. 39, page 445 (Rating table).
1900, No. 48, pages 178-179.
1901, No. 65, pages 290, 291 and 323, and No. 75, page 100.
1902, No. 83, pages 188-190.
1903, No. 98, pages 248-250 (contains description of new gage).
1903-1904, No. 128, page 72 (Rating table, etc.).
1904, No. 128, pages 71-73.
1905, No. 169, pages 58-59.
1906, No. 205, pages 47-48.
1907, No. 243, pages 83-84.
1907-1908, No. 243, page 84 (Rating table, etc.).
1908, No. 243, pages 83-84.
1909, No. 263, pages 88-89.
1910, No. 283, pages 78-79.
1911, No. 303, pages 51-52.
1912, No. 323, pages 56-57.
1912-1913, No. 353, pages 59-60.
1913-1914, No. 383, pages 58-59.
1895-1914, No. 383, pages 59-60 (Days of deficiency in discharge).
1914-1915, No. 433, page 66.
1915-1916, No. 433, page 74.
1916-1917, No. 453, page 54.
1915-1917, No. 453, pages 55-57 (Daily and monthly discharge).
1917-1918, No. 473, page 48.

Big Creek.—Big Creek, tributary to Greenbrier River from the north, heads against the southern slope of Keeney Mountain, flows generally southwestward and empties at Wiggins, its total length being 5.2 miles and the area of its drainage basin 10.83 square miles. About half-way between its head and its mouth there is considerable unnamed tributary on either side.

Powley Creek.—Powley Creek is a short, northern tributary of Greenbrier River, heading against a spur of Keeney Mountain 2½ miles northwest of Talcott and flowing southwestward 2 miles to the parent stream 1½ miles east of Wiggins, the area of its drainage basin being 2.28 square miles. On its lower course Bills Creek is a short tributary from the west.

Wolf Creek.—Wolf Creek, tributary to the Greenbrier from the south, rises against the eastern slope of Wolf Creek Mountain, flows generally eastward and empties into the parent stream at the extreme southwestern end of the Big Bend

one mile east of Buck. Its total length is 4.7 miles and the area of its drainage basin is 11.40 square miles, there being several unnamed tributaries of considerable size.

Little Stony Creek.—Little Stony Creek is a southern tributary of Greenbrier River, rising in Monroe County 1½ miles southwest of Wayside, flowing generally northwestward across the Summers County line and emptying in the Big Bend one-half mile west of Bargers Springs. Its total length is 4.5 miles and the area of its drainage basin 4.88 square miles, most of its valley being rough.

Stony Creek.—Stony Creek, tributary to the Greenbier on the south, heads in Monroe County at Wayside, flows northward 2 miles and then southwestward into Summers County, and empties in the Big Bend midway between Little Stony Creek and Bargers Springs. Its total length is 5.4 miles and the area of its drainage basin 6.74 square miles. Its upper basin is fan-shaped but farther down its valley is narrow and quite rugged, there being few tributaries.

Hungard Creek.—Hungard Creek, a northern tributary of the Greenbrier, rises against Keeney Mountain near Ballengee Knob, flows southeastward to a point three-fourths mile northwest of Pence Springs where it veers to the west and southwest with a course roughly parallel to the Greenbrier, and empties into the parent stream one-half mile west of Talcott. Its total length is 9.3 miles and the area of its drainage basin 18.35 square miles. Boone Creek is a considerable western branch at Boone School and Righthand Fork is a large eastern tributary at Bush School. There is much evidence for belief that Hungard Creek once entered the Greenbrier just opposite Pence Springs, since there is a low, rounded gap directly in line with its upper course, and if so the last one-third mile of the prehistoric channel was a tumultuous drop of approximately 200 feet from the level of the gap to the river. Its course appears to have been diverted from the gap by a stream which at that time was an eastern branch of Boone Creek and which finally scoured out the soft red shales that offered less resistance than the comparatively hard sandsatones upholding the gap, the process being easier because of the rapid western dip of the strata. This small

piratical stream and the portion of Boone Creek below Boone School then became the main valley of Hungard Creek and Boone Creek above Boone School was reduced to the status of a tributary.

Wind Creek.—Wind Creek, flowing into Greenbrier River from the south, rises in Monroe County 1½ miles south of Creamery, passes generally northwestward across the Summers County line and empties one-half mile south of and below Lowell. Its total length is 4 miles and the area of its drainage basin is 3.55 square miles, there being no tributaries of consequence.

Kelly Creek.—Kelly Creek, tributary to Greenbrier River from the south, rises in Monroe County about one mile southeast of Creamery, flows generally northwest across the Summers County line and soon thereafter veers southwestward, and empties at Lowell. Its total length is 5.8 miles and the area of its drainage basin 7.41 square miles. Flint Hollow is a considerable northeastern tributary at Creamery.

Wolf Creek.—Wolf Creek, tributary to Greenbrier River from the south, rises in Monroe County one-half mile northwest of Sarton, flows northeastward to Wolf Creek village and thence northwestward, emptying just south of Wolf Creek Station and just east of the Summers County line. Its total length is 11.7 miles and the area of its drainage basin 38.7 square miles, its principal named tributaries in ascending order being Laurel Creek, Broad Run, and Hardy Run. Almost its entire drainage is limestone land which has been largely cleared and devoted to agriculture or grazing.

Griffith Creek.—Griffith Creek, a northern tributary of Greenbrier River, rises in Summers County on the southern slope of Keeney Mountain just south of Keeney Knob, flows generally southeastward and empties just opposite Glenray. Its total length is 4.1 miles and the area of its drainage basin 6.26 square miles. Most of its valley is rough and wooded.

Muddy Creek.—Muddy Creek, tributary to Greenbrier River from the north, apparently has its beginning with the source of Flynn Creek at the southern end of Old Field Mountain, Greenbrier County. Flynn Creek flows southward and empties into Sinking Creek which flows southeastward to

Williamsburg in the limestone country and thence southwestward, but passes beneath a low ridge one mile southwest of Williamsburg. One-third mile farther southwest the same water emerges from the base of the ridge and continues its flow southwestward for 5½ miles but it again disappears beneath the topography 1½ miles southwest of Hughart, passes under the James River and Kanawha Turnpike (Midland Trail), and so remains for 3 miles with the exception of a brief reappearance in a deep sink just south of the turnpike. At Piercys Mill its subterranean flow ends and it is then known as Muddy Creek, its further course being tortuous but generally southwestward until it finally empties into the Greenbrier one mile below and west of Alderson and one-half mile east of the common corner of Greenbrier, Summers, and Monroe Counties. With the exception of a few branches which head in the edge of Summers the entire drainage is in Greenbrier County. The total length, starting at the head of Flynn Creek and following the stream line is 19.7 miles and the area of the drainage basin 116.41 square miles. The principal tributaries, in ascending order, are Mill Creek, Beech Run, Kitchen Creek, Alum Run, and Hughart Creek.

Second Creek.—Second Creek, tributary to Greenbrier River from the south, starts in southern Monroe County with the head of Kitchen Creek on the southern slope of Gap Mountain one-half mile north of Centennial. From this point Kitchen Creek flows westward through a fertile limestone valley to Gap Mills where it combines with Back Creek coming from the western end of the same valley and forms Second Creek. Second Creek then cuts deep passages through Gap Mountain and Little Mountain, flows generally northward until it reaches the Greenbrier County line 1½ miles north of Second Creek village, thence westward and northward to the river 1½ miles southeast of Fort Spring, most of its channel being tortuous and showing many ancient meanders. The topography along its course is quite varied, there being some localities where the soil is calcareous or shaly and well adapted to agriculture and grazing and others where the sandstone ledges of the Pocono Series largely preclude the idea of cultivation. Its total length from the head of Kitchen Creek

to Greenbrier River is 26 miles and the area of its drainage basin 116.34 square miles. The principal tributaries, in ascending order, are Rayburn Draft with a length of 3.6 miles and a drainage area of 3.7 square miles, Carpenter Creek with a length of 4.3 miles and a drainage area of 6.58 square miles, Laurel Creek with a length of 8.7 miles and a drainage area of 17.66 square miles, Forest Run with a length of 3.5 miles and a drainage area of 3.57 square miles, Devil Creek with a length of 3.8 miles and a drainage area of 10.24 square miles, Back Creek with a length of 3 miles and a drainage area of 8.89 square miles, and Kitchen Creek with a length of 5.2 miles and a drainage area of 10.37 square miles.

Bluestone River.

Bluestone River, tributary to New River from the west at True, Summers County, rises on the northern slope of East River Mountain 2 miles southwest of Springville, Tazewell County, Virginia, flows northeastward to Graham (now Bluefield), Virginia, where it makes a right-angle turn to the northwest and so continues to the vicinity of Bluestone and Coopers, Mercer County, having crossed into West Virginia at Flattop Yards. Near Coopers it again resumes its northeastward course and so continues to its mouth, the Mercer-Summers County line being crossed 2 miles southeast of Dunn. The length from its source to Graham is 13.5 miles, from Graham to Bluestone 8.4 miles and from Bluestone to its mouth 55.3 miles, making a total of 77.2 miles; and the area of its entire drainage basin is 463.54 square miles. Above Graham its course lies straight except for short meanders of recent origin. Between Graham and Bluestone it cuts gaps through several ridges of considerable height, its channel being somewhat devious but not of the true meandering type. In this section there are some localities where the valley is wide and well adapted to agriculture. From Bluestone and Coopers to its mouth the general alignment is remarkably straight and approximately parallel to the strike of the rock strata, but throughout this entire distance there are almost innumerable short entrenched meanders inherited from an-

cient times. Throughout this portion of its course, also, the topography is uniformly rugged and of little use for agriculture except in restricted localities where the valley widens. Between Coopers and Rock the region is thickly populated, being the outlet for a rich coal mining region lying just to the northwest, but below Rock the valley is sparsely settled and mostly difficult to traverse, there being no railroads and few county roads that are passable for an automobile.

Its principal tributaries, in ascending order, are Pipestem Creek, Surveyor Branch, Little Bluestone River, Mountain Creek, Laurel Creek, Indian Branch, Whiteoak Creek, Brush Creek, Camp Creep, Wolf Creek, Rich Creek, Blacklick Creek, Lashmeet Branch, Middle Fork, Widemouth Creek, Sandlick Creek, Crane Creek, Lorton Lick Creek, Flipping Creek, Simmons Creek, Mill Creek, Laurel Fork, Lick Branch, Big Branch, Mud Fork, Brushy Fork, Beaver Pond Creek, and Wright Valley Creek.

The United States Geological Survey and the West Virginia Geological Survey, in cooperation, maintained a gaging station for a few years at Lilly, Summers County, 2,000 feet below the mouth of Little Bluestone River, the station having been established August 22, 1908, and records having been kept from that date until January 13, 1912; also from July 21 to November 7, 1912; and from January 15, 1913, to September 30, 1916, when the station was discontinued. These records are published in the following Water-Supply Papers of the former organization:

1908, No. 243, page 81.
1909, No. 263, page 86.
1910, No. 283, pages 75-76.
1911, No. 303, pages 47-48.
1912, No. 323, page 53.
1912-1913, No. 353, page 57.
1913-1914, No. 383, pages 55-56.
1914-1915, No. 403, pages 63-64.
1915-1916, No. 433, pages 71-72.

Another gaging station was established by the same organizations on Bluestone River at Barker's Ford one mile above the mouth of the river and three-fourths mile above True, starting with October 17, 1911. The available records

of this station for the remainder of 1911, as kept by the United States Geological Survey, are published in Water-Supply Paper No. 303, pages 48-49, and those for 1912 in Water-Supply Paper No. 323, page 54. The station appears to have been discontinued December 31, 1912.

Pipestem Creek.—Pipestem Creek, tributary to Bluestone River from the southeast, heads in the southern edge of Summers County just east of Pipestem Knob, and flowing generally northward, empties at True. Its total length is 8.2 miles and the area of its drainage basin 13.70 square miles. Its course for the first two miles lies on the high plateau of Tallery Mountain, being upheld by the hard Princeton Conglomerate, but in the vicinity of Pipestem village it has broken down through this ledge and has cut a deep narrow channel in the red shales and softer sandstones of the Hinton Group. Except in the plateau section its valley walls are entirely too steep and rough for soil cultivation.

Little Bluestone River.—Little Bluestone River, entering Bluestone River from the northwest, heads in the western edge of Summers County 3 miles northeast of Flattop village and along the eastern slope of the mountain known partly as Flattop and partly as Whiteoak, flows first northeastward and then southeastward and empties at Lilly. It total length is 8.8 miles and the area of its drainage basin 34.85 square miles. Its valley is deep and narrow, being mostly too steep and rough for successful cultivation except where occasional brief stretches of alluvium have been formed. In ascending order, its principal tributaries with their respective drainage areas are: Suck Creek, 7.18 square miles; Sunrise Branch, 2.18 square miles; Parker Creek, 10.76 square miles; Whiteoak Branch, 2.43 square miles; and Spicelick Creek 2.56 square miles.

Mountain Creek.—Mountain Creek, tributary to Bluestone River, from the northwest, heads in Mercer County just south of its common corner with Raleigh and Summers and one mile east of Flattop village, and flowing southward and eastward empties in the northern edge of the same county two miles southeast of Dunn. Its total length is 8 miles and the area of its drainage basin 22.64 square miles, its valley being

deep and narrow and little suited to agriculture. Its principal tributaries in ascending order, with their respective drainage areas are: Dust Creek, 2.3 square miles; North Fork, 17.8 square miles; and Coal Branch, 2.78 square miles.

Laurel Creek.—Laurel Creek, flowing into Bluestone River from the northwest, rises in Mercer County 1½ miles east of Clark School and descends through a steep and narrow channel to the river one mile northeast of Ellison School, its length being 3.2 miles and the area of its drainage basin 3.52 square miles.

Indian Branch.—Indian Branch, tributary to Bluestone River from the southeast, heads at the Summers-Mercer County line three-fourths mile northeast of Lerona, flows southwestward through Mercer County and empties 1.3 miles east of Ellison School. Its total length is 3.7 miles and the area of its drainage basin 5.56 square miles, the first mile of its course being on the high plateau between Tallery and Bent Mountains and the remainder in a narrow and rapidly deepening valley. Its principal tributary is Laurel Branch.

Whiteoak Creek.—Whiteoak Creek, coming into Bluestone River from the southeast, rises in Mercer County at the western edge of the plateau one mile northwest of Pride, flows generally westward and empties one mile east of and below Eads Mills. Its length is 2.3 miles and the area of its drainage basin 2.12 square miles, there being two tributaries from the south which make its basin fan-shaped. The last half mile of its course is a deep and narrow notch in the topography.

Brush Creek.—Brush Creek, tributary to Bluestone River from the southeast, rises in Mercer County at the northern base of Stony Ridge 2 miles northeast of Bluefield, flows generally northeastward to Princeton and then, veering more toward the north, empties one-half mile east of and below Eads Mill. Its total length, from the head of South Fork to the mouth at Bluestone River, is 24 miles and the area of its drainage basin 74.49 square miles. Above Princeton its valley lies on the high Weverton Peneplain, with a comparatively wide, U-shaped cross-section, the stream being sluggish and having many meanders of recent origin which show that base-

leveling has been nearly accomplished. Between Princeton and Gardner the valley becomes narrower and the current is slightly accelerated, and below Gardner the stream becomes swift and the valley narrow and V-shaped with rugged walls on either side. Above Princeton the land is largely cleared and under cultivation. The principal tributaries in ascending order, with their respective drainage areas, are: Laurel Creek, 16.92 square miles; Little Laurel Creek, 2.31 square miles; Beaver Branch, 2.36 square miles; Christian Fork, 6.83 square miles; Glady Fork, 3.16 square miles; North Fork, 10.64 square miles; and South Fork, 10.65 square miles.

Camp Creek.—Camp Creek, coming into Bluestone River from the northwest, heads on Flattop Mountain in the western edge of Mercer County three-fourths mile west of Barn, flows generally southeastward and empties one-half mile west of and above Eads Mill. Its total length is 12.3 miles and the area of its drainage basin 41.27 square miles. Its upper valley above Mash Fork is rough, wooded and thinly populated, but below Mash Fork there are some comparatively wide alluvial bottoms and the land is partly devoted to agriculture. The principal tributaries in ascending order, with their respective drainage areas, are: Trace Creek, 2.6 square miles; Mash Fork, 13.6 square miles; Bear Creek, 2.64 square miles; and Mill Branch, 3.02 square miles.

Wolf Creek.—Wolf Creek, entering Bluestone River from the northwest, rises near Willis White School, and flowing eastward empties 1.7 miles south of Camp Creek village, its length being 4.0 miles and the area of its drainage basin 5.78 square miles.

Rich Creek.—Rich Creek, tributary to Bluestone River from the northwest, heads against the eastern slope of Flattop Mountain in the western edge of Mercer County one mile southwest of the common corner with Raleigh and Wyoming Counties, flows generally southeastward and empties at Spanishburg. Its length is 9.8 miles and the area of its drainage basin 22.51 square miles. The upper portion of its valley is rough and thinly populated but along the lower two miles of its course there are wide bottoms under cultivation. Its

principal tributary is Pocosin Fork with a drainage area of 5.81 square miles.

Blacklick Creek.—Blacklick Creek, coming into Bluestone River from the southeast, rises on the south side of Blackoak Mountain 4 miles west of Princeton, flows northeastward for 4 miles and then turns northward, and cutting a passage around the northeastern end of the mountain empties 1.4 miles south of and above Spanishburg. Its length is 7 miles and the area of its drainage basin 8.72 square miles. Most of its valley is rough and thinly settled. Rocky Branch and Barn Branch are short tributaries.

Widemouth Creek.—Widemouth Creek tributary to Bluestone River from the northwest, heads in the western edge of Mercer County on the eastern slope of Flattop Mountain just east of Black, and flowing generally southward empties just north of and below Rock. Its length is 12.2 miles and the area of its drainage basin 25.46 square miles. Throughout its length the topography is rugged and the valley extremely narrow but part of it is traversed by two lines of railroad and the portion above Matoaka is devoted to coal mining and supports a dense population. Its principal tributaries are Righthand Fork with a drainage area of 11.23 square miles and Lefthand Fork with a drainage area of 5.63 square miles.

Sandlick Creek.—Sandlick Creek, entering Bluestone River from the southeast, heads against Redoak Ridge about three-fourths mile northwest of Littlesburg, flows northward and northwestward and empties three-fourths mile northwest of and above Rock, its length being 2.7 miles and the area of its drainage basin 3.06 square miles. With the exception of a small amount of smooth land near its head the gradient is steep and the topography rough.

Crane Creek.—Crane Creek, tributary to Bluestone River from the northwest, rises at the eastern base of Flattop Mountain in the western edge of Mercer County west of Mannering, flows generally southeastward and empties at Montcalm. Its length is 6.6 miles and the area of its drainage basin 12.31 square miles. Its principal tributaries, in ascending order, are Jims Branch, Lower Georges Branch, Belcher Branch,

Upper Georges Branch, Tolliver Branch, and Red Hollow. The valley is very narrow and the topography rugged but it is traversed by a railroad and there is a thick population supported by the coal mining industry.

Lorton Lick Creek.—Lorton Lick Creek, entering Bluestone River from the southeast, heads on the southern slope of Redoak Ridge 1.3 miles northeast of Brush Fork village, cuts passages through Redoak and Micajah Ridges, and with a devious but generally northward course reaches the parent stream one-third mile south of and above Montcalm. Its length is 4.5 miles and the area of its drainage basin 4.8 square miles. Its narrow valley is thinly settled and the land is mostly rough.

Flipping Creek.—Flipping Creek, tributary to Bluestone River from the northwest, rises in southwestern Mercer County 2 miles northwest of Goodwill, flows southeastward and empties at Flipping, its length being 4.2 miles and the area of its drainage basin 4.17 square miles. Its valley is narrow and its topography rough but it supports a considerable coal mining population.

Simmons Creek.—Simmons Creek, coming into Bluestone River from the northwest, heads in southwestern Mercer County 2.3 miles northwest of Goodwill, flows southeastward and empties at Simmons, its length being 3.2 miles and the area of its drainage basin 4.02 square miles. Its rough and narrow valley contains a dense mining population.

Mill Creek.—Mill Creek, entering Bluestone River from the northwest, rises in Mercer County one mile northeast of the common corner with McDowell County, West Virginia, and Tazewell County, Virginia, flows southeastward and empties at Coopers, its short length of only 2 miles and its drainage area of only 2.06 square miles being thickly populated by the coal mining industry.

Laurel Fork.—Laurel Fork, tributary to Bluestone River from the southwest at Bluestone and near the right-angle turn of the parent stream that occurs between Bluestone and Coopers, rises in Tazewell County, Virginia, at the southern base of Big Stone Ridge 1½ miles west of Smith Store, flows northeastward and empties in West Virginia, there being only about

one mile of its channel in the latter State. Its length is 11.8 miles and the area of its drainage basin 26.6 square miles, its principal tributaries in ascending order being Coal Run, Reeds Run, Jonathan Branch, Haynes Branch, Curran Branch, and Farmers Branch. The topography is rough and the valley narrow, with numerous short meanders inherited from ancient times. In the lower portion a thick coal mining population is supported.

Lick Branch.—Lick Branch, coming into Bluestone River from the northeast, rising in Mercer County and having all its drainage therein, heads one-half mile southeast of Pinnacle Rock, flows generally southwestward and empties in the bend north of Nemours. Its length is 2 miles and the area of its drainage basin 1.72 square miles.

Mud Fork.—Mud Fork, tributary to Bluestone River from the southwest, rises in Tazewell County, Virginia, 3 miles northeast of Adria, flows generally northeast and empties at Falls Mills, Virginia. Its length is 13 miles and the area of its drainage basin 20.24 square miles. The valley has a considerable rural population, being devoted to agricultural pursuits.

Brushy Fork.—Brushy Fork, entering Bluestone River from the northeast, rises in Mercer County one-half mile southwest of Littlesburg, flows southwestward and empties at Falls Mills, Tazewell County, Virginia, the last mile of its course being in the latter county. Its length is 6.7 miles and the area of its drainage basin 11.18 square miles. Its valley for the most part is wide and fertile, supporting a considerable rural population.

Beaver Pond Creek.—Beaver Pond Creek, tributary to Bluestone River from the east, rises in Mercer County one mile east of Bluefield, West Virginia, flows southwestward across the Tazewell County line and later turns northwestward, emptying just below and northwest of Graham (now Bluefield), Virginia. Its length is 4.8 miles and the area of its drainage basin 9.36 square miles. Crenshaw Branch, along which is located the main line of the Norfolk & Western Railway, is its principal tributary. There is a large proportion of limestone land both along the main creek and on

Crenshaw Branch but a large part of it is occupied by the cities of Bluefield, West Virginia, and Bluefield, (formerly Graham), Virginia, so that little opportunity is afforded to cultivate the soil.

Wright Valley Creek.—Wright Valley Creek, tributary to Bluestone River from the southwest, rises at Tiptop, Tazewell County, flows generally northeast and empties just west of Graham in the same county, its length being about ten miles. The Clinch Valley Division of the Norfolk & Western Railway passes up this valley, and there is also a considerable rural population, the soil being partly of calcareous derivation and the bottoms moderately wide.

East River.

East River, tributary to New River from the west at Glenlyn, Giles County, Virginia, rises at Bluefield, Mercer County, West Virginia, and flows northeastward by a very direct course, all of its channel being in Mercer County except the last half mile. Its main valley is very narrow being restricted on the south by East River Mountain and its foothills and on the north by Stony Ridge and its northeastward topographic expression, there being two or three tributaries which have broken through this northern barrier and which augment its drainage. Its total length from head to mouth is 23 miles while the air-line distance between the same points is 21.3 miles. The area of its drainage basin is 77.31 square miles. The comparative youth of this valley is apparent, its rate of fall from head to mouth being 45.22 feet per mile and there being little bottom land. Throughout its length it is traversed by the main line of the Norfolk and Western Railway and for part of the distance by that of the Virginian Railway. The soil is varied, there being an outcrop of limestone along a considerable portion of the immediate valley and another broad belt along a high shelf that generally occurs at the base of East River Mountain, while the land between is largely sandstone and sandy shales which are slow to disintegrate. On the north slope there are abundant red shales but the profile is steep and often deeply buried under sand-

stone debris from the top of Stony Ridge. The principal tributaries, in ascending order, are Big Spring Branch, Pigeon Creek, Fivemile Creek, Harmon Branch, and Twelvemile Creek.

Big Spring Branch.—Big Spring Branch, entering East River, from the south, heads against the slope of East River Mountain 2½ miles southeast of Oakvale, flows northeastward and empties just west of and above Wills Station. Its length is 4.2 miles and the area of its drainage basin 6.47 square miles, Trimble Branch being its main tributary. Its flow is greatly augmented and made perennial by a large spring which emerges from the Beekmantown Limestone at an elevation of 2,000′ B., 0.3 mile southeast of the St. Clair Fault and 0.9 mile southwest of Neel School, being about 400 feet above the level of East River at Wills Station. The writer has already suggested this spring as one of the most hopeful sources of supply for the cities of Princeton and Bluefield. To Princeton the air-line distance is 10 miles and the lift to the level of the court-house about 450 feet. To Bluefield the air-line distance is 17 miles and the lift to the level of the United States Geological Survey bench mark near the Norfolk & Western Railway Station about 565 feet.

Pigeon Creek.—Pigeon Creek, tributary to East River from the south, rises at the foot of East River Mountain one mile northeast of Buckhorn Knob, generally northeastward and empties one-half mile east of and below Oakvale. Its length is 2.8 miles and the area of its drainage basin 5.32 square miles. There are fertile limestone coves at the head of the creek and there is also limestone at the mouth but the intervening topography is rough and poor.

Fivemile Creek.—Fivemile Creek entering East River from the north, heads just east of Elmore School, Mercer County, flows eastward to Goodwyn Chapel where it turns southeastward and cuts gaps through two ridges of considerable height and empties about one-half mile east of and below Oakvale, or just above the mouth of Pigeon Creek. Its length is 5.6 miles and the area of its drainage basin 21.4 square miles. Its principal tributaries, in ascending order, are Hales Branch with a length of 2.6 miles and a drainage area of 3.83

square miles, and Payne Branch with a length of 5.8 miles and a drainage area of 9.61 square miles. Johnson Hollow and Possum Hollow are short streams with deep narrow valleys which enter from opposite sides in the locality of the gaps. All of the topography is rough and rugged there being numerous heavy sandstones bedded in the outcropping red shales.

Twelvemile Creek.—Twelvemile Creek, tributary to New River from the north, rises in Mercer County about one-half mile northeast of Billie, flows eastward and then southward, and cutting a deep gap through Stony Ridge in the lower mile of its course, empties at Ingleside. Its length is 4 miles and the area of its drainage basin 8.05 square miles, Rocky Hollow being its main tributary. All the topography is rough and rugged, part of the valley being traversed by the main line of the Virginian Railway which winds through the coves at a high level above the creek.

Jackson River (of James) Drainage.

The southeastern corner of Monroe County is drained by several creeks which either flow directly into Jackson River or reach it through the medium of major tributaries. Jackson River in turn unites with Cowpasture River in Botetourt County, Virginia, three miles below Clifton Forge, to form the James which is one of the few rivers carrying West Virginia drainage directly to the Atlantic Ocean instead of by the roundabout route through the Gulf of Mexico.

Cove Creek.—Cove Creek rises in Monroe County between Cove and Middle Mountains near Wylie Church, flows northeastward for about three miles, then turns southeastward, cutting a deep gorge through Middle Mountain and other ridges for another three miles, then suddenly turns northeastward again, and crossing the Virginia State line unites with Sweet Springs Creek to form Dunlap Creek near Iron Hill Spring 2½ miles east of the Monroe County line, and through the latter channel its waters reach Jackson River at Covington, Virginia. Its total length is 8.2 miles and the area of its drainage basin 26.38 square miles, of which 12.36 square miles are above the mouth of Back Creek. In its upper valley the

lowlands between the mountains are mostly composed of limestone and red shale which make good soil but in the gorge farther down the topography is rough and the valley narrow and tortuous and of small value for agriculture. Back Creek, its principal tributary, rises at Roxalia, Monroe County, flows northeastward and empties at Cove Creek School one-half mile west of the Virginia line, its length being 6 miles and the area of its drainage basin 8.02 square miles, its valley being rough, wooded and having only a few habitations.

Sweet Springs Creek.—Sweet Springs Creek rises just east of Centennial, Monroe County, flows northeastward in a deep valley between Gap and Moss Mountains on the north and Peters Mountain on the south, crosses into Alleghany County, Virginia, one-half mile northeast of and below Sweet Springs, and unites with Cove Creek to form Dunlap Creek at Iron Hill Spring as above mentioned. Its length is 9.2 miles and the area of its drainage basin 18.70 square miles, that portion above the Virginia line being 12.52 square miles. Its immediate valley is rich limestone and chert land, the slopes being gentle enough for successful farming, but higher up toward the crests of the ridges the soil changes and the land becomes rough.

Potts Creek.—Potts Creek, the South Fork of which has the greatest length, rises in the southwestern corner of Monroe County 4 miles southwest of Waiteville, flows northeastward to a point about one mile east of Laurel Branch where it becomes the line between Monroe County, West Virginia, and Craig County, Virginia, but about one mile farther on it passes entirely into Craig County and continuing in the same general direction it empties into Jackson River three miles south of and below Covington. Its length from head to mouth is 42 miles and that from its head to Paint Bank, Virginia, 16.5 miles; and the area of its entire drainage basin is 174.65 square miles, that above Paint Bank Branch being 55.54 square miles. Its entire basin is a magnificent, land-locked valley, hemmed in on the north by Peters and Sweet Springs Mountains and on the south by Potts Mountain, there being a few gaps through these high ranges. Above Paint Bank the principal tributaries, in ascending order, are Ewin Run with a length

PLATE V.—View from road one-fourth mile north of Pickaway, Monroe County, looking southward toward Union. Wide valley is Harrisburg Peneplain, the drainage being submerged through sink-holes in Greenbrier. Swoopes Knobs at right are crowned by Bluefield Group and represent Schooley Peneplain. Part of Pickaway village in left foreground, and Peters Mountain in extreme left rear almost obscured by haze. (Photo. by Palmer & Fowler).

of 3.5 miles and a drainage area of 4.46 square miles, Trout Branch with a length of 2.8 miles and a drainage area of 3.26 square miles, and North Fork with a length of 5 miles and a drainage area of 8.27 square miles. The total length of South Fork is 5.8 miles and its drainage area 11.54 square miles, its main tributaries being Ray Fork with a drainage area of 1.03 square miles and Crosier Branch with a length of 3 miles and a drainage area of 2.35 square miles. From the head of South Fork to Paint Bank the valley is traversed by a branch line of the Norfolk and Western Railway. With the exception of a little bottom land immediately along the creek and a few limestone coves in the Back Valley at the heads of Paint Bank and Ewin Runs, nearly all the land above Paint Bank is rough and unproductive being mostly cut-over woodland. Below Paint Bank no investigation of the valley was made.

PART II.

Geology.

CHAPTER III.

GEOLOGIC HISTORY AND CORRELATION OF ROCKS.

DERIVATION OF SEDIMENTS.

The outcropping arenaceous rocks of Mercer, Monroe, and Summers Counties are entirely of sedimentary, or clastic, origin. They represent the broken and pulverized remains of still older rocks of the earth that have been slowly torn to bits, mainly by the agency of meteoric water, but also in part by atmospheric or chemical action, the whole process having been materially aided and hastened by diastrophism which both wrinkled and crushed the ancient surface. From their original position these rock fragments have been transported long distances by the prehistoric rivers that had their sources in a great mountain range, often called **Appalachia** for convenience, that is known to have existed in the vicinity of the present Atlantic seaboard and the region immediately westward, and that must have been of great height to afford the necessary gradient required for carrying the sedi-

ments to their present position. From this ancient land of high relief a vast quantity of rock debris was carried eastward and deposited in the Atlantic Ocean, forming what is known as the Continental Shelf, the peculiarities of which are largely unknown because of its present submergence. At the same time another large mass of sediments was carried westward toward the Mississippi Valley and deposited in the ancient Appalachian Sea that extended from the Gulf region northward into Canada, the waters of which were comparatively shallow, with many large embayments of brackish or fresh constituents due to the inflow from the rivers.

As the burden of sediments increased in this old basin its floor gradually subsided, allowing fresh deposits to cover those already made, and at the same time causing isostatic adjustments which, with the probable aid of magmatic disturbances, raised new lands in the region of Appalachia and also uplifted portions of the newly formed beds just west of the original land area, affording further material for the old rivers to tear down and transport. This process of alternate uplift and erosion continued for well-nigh infinite ages until now the primeval mountains have been entirely degraded, leaving nothing but their ancient stumps deeply buried under a mantle of much later accumulation in the Piedmont and Coastal Plain provinces, the high ridges of Appalachia having moved slowly westward by successive upheavals until they now occupy their present positions in the eastern locus of the ancient Appalachian Sea.

Some idea of the composition of ancient Appalachia may be gained from a study of the present arenaceous rocks. These have a predominant base of silica, mostly in the form of small grains of sand with much less frequent occurrence of quartz pebbles of varying size, the remainder of the stone being generally made up of particles of mica, finely divided feldspatic material, alumina, compounds of iron, and calcareous matter. Quartz, mica, and feldspar are the most abundant constituents of granite and by their abundance in the present rocks indicate the probable magma that must have composed the original core of Appalachia.

In some of the sandstones of the three counties, more particularly those of the Mauch Chunk beds of Mississippian age, there are pebbles of shale and limestone which are evidently of more recent origin than the materials above discussed, since neither shale nor limestone will withstand long exposure or long-continued attrition. These pebbles evidently came from stratified beds somewhat older than the present matrix which contains them but vastly younger than the granitic magma which formed the main bulk of Appalachia, and from a geographic zone of deposition that lay between the original mountains and the present location of the pebbles but probably only a comparatively few miles from the latter. Naturally, the beds of limestone and shale must have been elevated from their original plane to the western flank or perhaps the summit of some range that even now may still exist, and that must have been of great linear extent since the limestone and shale pebbles are not confined to the counties under discussion alone but continue for several hundred miles northeastward and southwestward along the strike of the Mauch Chunk rocks.

In the region southeast of the Mauch Chunk outcrops of the three counties limestones of earlier age and of sufficient purity to give effervescent reactions are found in the Greenbrier Series, coming just below the Mauch Chunk, in the Martinsburg, coming many thousands of feet farther down, and in the Stones River (Chickamauga), occurring at a comparatively small interval below the Martinsburg. Positive evidence as to the group from which these pebbles may have come is almost wholly lacking since there have been found in the pebbles only traces of fossil life which are too faint for recognition. A suggestion as to their origin, however, is afforded by a comparison with the Moccasin Limestone of the Ordovician which is preeminently calcareous but yet contains much clay and many shale particles that distinctly outclass it from a limestone built up in place by animal remains, besides being apparently barren of fossil life. The Moccasin Limestone occurs just above the very pure Stones River (Chickamauga) and may have derived its sediments from the rapidly eroding surface of the latter along the flank of some

old range, the calcareous ooze so formed being mixed and polluted by mud and shale during its transit toward the waters of Moccasin age. In the case of the Mauch Chunk pebbles it is of much significance to note that the series is underlain by the pure limestone beds of the Greenbrier, the eastern portion of which may have been tilted upward in time to provide the pebbles that were deposited in late Mauch Chunk time. The adoption of such a theory would naturally embrace the premise that the slope of erosion was in a neighboring range, since there is little evidence that any Greenbrier beds ever existed far to the southeastward, and would be in harmony with the belief that the non-resistant pebbles could not have been carried far to sea.

The sum total of sediments now accumulated on the floor of the Appalachian Basin is variously estimated from 40,000 to 60,000 feet, consisting in part of the sandy remains of Appalachia, which by differential sorting of the fragments have been separated into sandy beds composed of the coarser quartzitic portions of the old granites, accumulated near the source of the waters or else much farther westward at times of excessive flow; and into shales composed of those portions in which the alumina and the finer sand grains predominated, allowing them to be carried farther into the basin or deposited along its edge during periods in which the waters flowed gently.

The calcareous sediments, in which lime predominates and which form a considerable part of the surface rocks of the three counties, are derived from the remains of vast quantities of animal organisms which flourished in the Appalachian Sea or in its shallow embayments of fresher water during periods in which degradation from Appalachia was not active and the waters were clear. A large amount of this material still remains approximately in its original position, but some portions have been transported for comparatively short distances and have been contaminated in part by mixture with sand or silt from the rivers of Appalachia.

A very small fraction of the surface rocks of the three counties is composed of the coals, which represent the accumulation of vegetable matter that grew in extensive

swamps during stages when the basin floor was elevated almost to the surface of the water, affording the peculiar condition in which plants might grow and at the same time be preserved from oxidation as the land gently subsided. A further more rapid subsidence caused these beds of vegetable remains to be buried under a mantle of sand and shale, thus preserving them until heat and pressure could gradually drive out the moisture and consolidate them into coal. Within the three counties the principal beds of coal are found only in rocks of the Pennsylvanian Period which outcrop along the western edges of Mercer and Summers Counties and with which this Report deals only incidentally, since these deposits have already been described[1]. In the Mauch Chunk and Pocono Series of the Mississippian Rocks, however, there are several thin and relatively unimportant coals which indicate that short stages favorable to the growth and preservation of coal plants occasionally prevailed even during these early times. Each coal bed represents an interval of extremely shallow water, quite in contrast to the more abundant cover of liquid that followed, indicating numerous subsidences of the old basin floor.

CYCLES OF UPLIFT AND EROSION.

The arenaceous, calcareous, and bituminous sediments of the three counties, subsequent to their original deposition as above described, have been deformed, both during their periods of formation and in more recent times. As described under the subject of "Evolution of Mountain Forms", pages 55-59, four distinct major cycles of uplift and erosion have occurred in the region under study, the present cycle having partly advanced through the erosional phase. In addition to these major cycles there have been numerous intermediate stages of gentle uplift or depression which were not of sufficient magnitude or duration to form mountains.

[1]C. E. Krebs, Report on Raleigh County and Western Portions of Mercer and Summers Counties, West Virginia Geol. Survey; 1916.

FAUNAL STAGES.

The oscillations of the early seas in the Appalachian Basin are reflected in the fossil life of the sediments deposited during the various periods of accumulation. Disregarding the Quaternary, or Alluvial, deposits which are of comparatively youthful age and entirely of fresh-water origin, and starting with the Pennsylvanian Period, the New River and Pocahontas Groups of the Pottsville Series, which outcrop in the northwestern parts of Mercer and Summers Counties, are known to have only a scanty fauna. In the New River the fossils are mainly of fresh- or brackish-water origin, **Lingula** and **Orbiculoidea** being the infrequent marine exceptions, but no fauna of any sort was observed in the limited area of these beds studied in the present Report. In the Pocahontas Group the fauna has been reported as wholly non-marine and of infrequent occurrence, and in Summers County only one lot of brackish- or fresh-water fossils was found.

In the Mississippian Period there is an abundance of marine fossils at numerous stages in the three counties, there being many varieties and often vast numbers of individuals of certain species. The Mauch Chunk Series contains fossils in all of its four major groups except the Princeton Sandstone. In the Greenbrier Series, coming just below the Mauch Chunk, there is a profuse and varied marine fauna throughout most of its members, certain of its more arenaceous or shaly stages being comparatively, but usually not wholly, barren. In the Maccrady Series, lying just below the Greenbrier, there appear to be few marine fossils along the outcrops in Mercer and Monroe Counties, their presence having been noted at only two or three points. In Smyth County, Virginia, however, which is the type locality of the series, it is abundantly fossiliferous. The northward partial disappearance of its fauna may be accredited to the fact that its limestones and calcareous shales are mostly absent, leaving little except the reddish shales that may not be entirely of subaqueous deposition. In the Pocono Series, which lies just below the Maccrady and which is the basal group of the Mississippian of the three counties, there are several well-defined marine stages.

For many years this series has been considered as practically non-marine, the few recorded instances of fossils being regarded as isolated instances of marine invasions into a generally fresh-water sea. In this belief the writer has usually concurred but an intensive study of the series which he has conducted in the past few years in most of the region where it has been so called, and in other regions where its stratigraphic equivalents have been locally designated by other titles, has resulted in the rather astonishing revelation that it generally carries one or more marine beds for a distance of approximately 450 miles from east-central Pennsylvania to the region of its southern disappearance as an easily recognizable group in east-central Tennessee. A more detailed statement of this fact will appear in a latter Chapter.

In the Devonian Period fossils of the Chemung, Portage, Genesee, Hamilton, Marcellus, Oriskany, and Helderberg Series have been recognized at various outcrops in Mercer and Monroe Counties, but generally speaking the Portage appears to be almost barren and the specimens in the Marcellus and Oriskany are often metamorphosed to the point of practical obliteration, and the Helderberg also is greatly attenuated.

In the Silurian Period the Clinton Series exhibits several marine stages. The White Medina (Clinch, Tuscarora) contains **Arthrophycus** and **Scolithus**, the affinities of which are not well established. The Red Medina (Juniata, Bays) Series contains, in addition to **Arthrophycus**, a very sparing fauna of recognized marine aspects. The Gray Medina, if it has been properly identified, appears to be represented by not more than two feet of sandstone which contained no fossils at its only known point of exposure.

In the Ordovician Period the Martinsburg (Sevier) Series carries abundant faunas of Lower Maysville, Eden, and Trenton age, the exposures for their study in Mercer and Monroe Counties being all that could be desired. In the Moccasin Limestone, which underlies the Martinsburg, no marine life of any description was recognized. In the Stones River (Chickamauga) Limestone the imprints of fossils may be found throughout most of its thickness but at many localities

they have been crystallized beyond recognition, there being a few localities, however, where passably good collections can be made. In the Beekmantown Limestone, coming below the Stones River, fossils of this age were recognized from the base of the Stones River downward for an approximate interval of 2,500 feet, although they were found only in the weathered cherts, no single instance of their occurrence in the dolomitic matrix having been noted in either Mercer or Monroe County where the beds outcrop. In the cherts the sparse fauna blends so readily with the cavities of the usually scoriaceous container that many days may often be spent without finding a single specimen.

Beneath the lowest recognized beds of Beekmantown Limestone there are exposed in Mercer and Monroe Counties approximately 1,000 feet of dolomite in which no vestige of marine life was found in either Mercer or Monroe County, the same barren character being noted in adjacent portions of Virginia. Dr. Prouty (in a letter) has stated his belief that this group may represent the Elbrook Limestone of the Cambrian Period, and the writer concurs in this belief, but in the absence of any positive proof it has been mapped as Beekmantown.

In Chapters VI-XII, inclusive, the stratigraphy of the above-named faunal stages, as determined by the writer, will be presented in detail, and in Chapter XVIII the faunas of the Pennsylvanian and Mississippian Periods as determined by Dr. George H. Girty of the United States Geological Survey and as listed and discussed by him, and those of the Devonian, Silurian, and Ordovician Periods, as studied and described by Dr. Prouty of the West Virginia Survey Staff, may be consulted.

FOSSIL FLORA.

In the Pennsylvanian Rocks there is, of course, an abundant and varied fossil flora, which has been studied in West Virginia and other Appalachian States by many noted authorities, including Dr. David White of the United States Geological Survey. In Mercer and Summers Counties, especially

in the portions with which this Report strictly deals, these rocks occupy only a narrow fringe of the northwestern part, and the study of their flora has not been considered essential or germane to this volume.

In the rocks of the Mississippian Period, however, the three counties offer most interesting floras at numerous stages of the Mauch Chunk, Greenbrier, and Pocono Series. The stratigraphy of these floras, as determined by the writer, will be presented in Chapters VII-IX, inclusive; and their professional discussion by Dr. David White will be found in Chapter XVII.

PREVIOUS GEOLOGIC WORK.

Numerous general and special publications have been issued within the past century, sections and items of which are applicable to the geology, natural resources, history, and climate of Mercer, Monroe, and Summers Counties. These publications are summarized in the following bibliography, but the list is doubtless far from complete and apology is offered to writers who may have been overlooked. Water-Supply Papers of the United States Geological Survey, dealing with New River and its tributaries, have already been noted under the descriptions of the drainage basins in Chapter II and are not repeated:

1833.—Featherstonehaugh, G. W. An account of the Travertin deposited by the Waters of Sweet Springs in Alleghany County in the State of Virginia, and of an ancient travertin discovered in the adjacent hills. Trans. Geol. Society, Penn., Vol. I, 6 pp.

1840-1842.—Rogers, W. B. and H. D. On the Physical Structure of the Appalachian Chain, as Exemplyfying the Laws which have Regulated the Elevation of Great Mountain Chains Generally. Trans. Assoc. American Geologists and Naturalists. (Reprinted in Geology of the Virginias, D. Appleton & Co. 1884, pp. 601-642.)

1843.—Rogers, H. D. An inquiry into the origin of the Appalachian Coal Strata, Bituminous and Anthracite. Trans. Assoc. of American Geologists. 41 pp.

1850.—Rogers, H. D. On the Structural Features of the Appalachians, compared with those of the Alps and other Disturbed Districts of Europe. Proc. Am. Assoc. for the Advancement of Science, Vol. II, 5 pp.

1858.—Rogers, H. D. Classification of the Several Types of Orographic Structure visible in the Appalachians and other Undulated Mountain Chains. Geology of Pennsylvania, Vol. II, 24 pp., Philadelphia.

1861.—Lesley, J. P. On the Subconglomeratic or False Coal Measures of Northwestern Virginia. Proc. Amer. Phil. Soc., Vol. VII, ¼ page.

1861.—Rogers, W. B. A Comparison of the lower Carboniferous of Nova Scotia and New Brunswick with Certain Groups in the Appalachian Belt in the United States. Proc. Boston Soc. Nat. Hist., Vol. VII, 3 pp.

1865.—Lesley, J. P. Appalachian Structure. Proc. Amer. Phil. Soc., Vol. IX, 14 pp., with plates.

1868.—Chesapeake and Ohio Railroad. History of the Chesapeake and Ohio Railroad. Resources of the country and legislation of Virginia and West Virginia, with a map showing its connection with the Pacific Railroad. Richmond, Va.

1870.—Walton, George E. The Mineral Springs of the United States and Canada with Analyses and Notes on the prominent Spas of Europe. Third edition, 1883, Cincinnati.

1877.—Fontaine, Wm. M. Notes on the Vespertine Strata of Virginia and West Virginia. Amer. Jour. Sci., Vol. XIII, 11 pp.

1881.—Stevenson, John J. Notes on the Quinnimont Coal Group in Mercer County, West Virginia. The Virginias, December, 1881, 2 pp.

1884.—Rogers, W. B. Geology of the Virginias. A reprint of the Annual Reports and other papers on the geology of the Virginias. One volume, 832 pp. Appleton & Co., New York. Contains a geological map of the Virginias and more than a hundred colored sections, made across all parts of the Virginias by Professor Rogers and his assistants, and most of them now engraved for the first time.

1886.—Peale, A. C. List and Analyses of the Mineral Springs of the United States. Bull. No. 32, U. S. Geol. Survey; West Virginia section, 5 pp.

1887.—Stevenson, John J. Notes on the Lower Carboniferous Groups along the Easterly Side of the Appalachian Area in Pennsylvania and the Virginias. Amer. Jour. Sci., Vol. XXXIV, 7 pp.

1891.—White, I. C. Stratigraphy of the Bituminous Coal Field in Pennsylvania, Ohio, and West Virginia. Bull. No. 65, U. S. Geol. Survey, 212 pp., 11 plates and a colored folded map.

1893.—Summers, George W. The Mountain State: A Description of the Natural Resources of West Virginia. Prepared for distribution at the World's Columbian Exposition. 260 pp., and a map of West Virginia.

1893.—Willis, Bailey. The Mechanics of Appalachian Structure. Thirteenth Annual Report, U. S. Geol. Survey, 68 pp. and 50 plates.

1896.—Campbell, M. R. Pocahontas Folio, No. 26, U. S. Geol. Survey. 5 pp. of text, 4 maps, and columnar section.

1897.—Campbell, M. R., and Mendenhall, W. C. Geologic Section from Charleston, West Virginia, to Hinton, West Virginia, along the Kanawha and New Rivers. 17th Annual Report, U. S. Geol. Survey, 32 pp., with large colored section.

1899.—White, I. C. Petroleum and Natural Gas, Levels, True Meridians. Vol. I, W. Va. Geol. Survey, 392 pp.

1901.—Brown, S. B. Bibliography of Works upon the Geology and Natural Resources of West Virginia from 1764 to 1901, and also a Cartography of West Virginia from 1737 to 1991. Bull. No. 1, W. Va. Geol. Survey, 85 pp.

1902.—Campbell, M. R. Raleigh Folio, No. 77, U. S. Geol. Survey, 8 pp. of text, 4 maps, columnar sections of stratigraphy and coal beds.

1903.—**White, I. C.** Coal Report. Vol. II, W. Va. Geol. Survey, 725 pp. General description of coals of the State, with sections, analyses, etc.

1904.—**White, I. C.** Petroleum and Natural Gas. Vol. I(a), W. Va. Geol. Survey, 625 pp. History of oil and gas development in State, statement of Anticlinal Theory, statistics of production, descriptions of oil and gas sands and many well records.

1904.—**Lewis, Virgil A.** Handbook of West Virginia. Published by West Virginia Commission of the Louisiana Purchase Exposition, 390 pp. History, Natural resources, enterprises, and institutions (popular style).

1905.—**Grimsley, G. P.** Clays, Limestones, Cements. Vol. III, W. Va. Geol. Survey, 565 pp. General study of these items in State.

1906.—**Johnston, David E.** History of the Middle New River Valley and Contiguous Territory. Standard Printing and Publishing Co., Huntington, W. Va., 500+xxx pp. Historical, political, and personal with some economic and mineral data.

1908.—**White, I. C.** Supplementary Coal Report. Vol. II(A), W. Va. Geol. Survey, 720 pp. Further sections, analyses, and comment on coals of State.

1908.—**Miller, James H.** History of Summers County, West Virginia. Published by James H. Miller, Hinton, West Virginia, 838 pp. General history of county. Contains data on prehistoric remains and mineral springs.

1909.—**Grimsley, G. P.** Iron Ores, Salt, Sandstones. Vol. IV, W. Va. Geol. Survey, 603 pp. General description of these items in State.

1911.—**White, I. C.** Levels and Coal Analyses. Bulletin No. 2, W. Va. Geol. Survey, 385 pp. Compilation of railroad and government levels, and State coal analyses to date of publication.

1911.—**Brooks, A. B.** Forestry and Wood Industries. Vol. V, W. Va. Geol. Survey, 500 pp. Describes these items in State.

1913.—**Millspaugh, C. F., and White, David.** Part I, Living Flora of West Virginia (Millspaugh); Part II, Fossil Flora of West Virginia (White). Vol. V(A), W. Va. Geol. Survey, 491 pp. General description of these items in State.

1916.—**Krebs, C. E.** Detailed Report on Raleigh County, Summers County west of New River and the Coal Area of Mercer County. W. Va. Geol. Survey, 778 pp. Detailed geologic report on the territory named, including Jumping Branch District, Summers County, and Jumping Branch and Rock Districts, Mercer County, with separate atlas of topographic and geologic maps.

1916.—**Morton, Oren F.** History of Monroe County, West Virginia. The McClure Company, Inc., Staunton, Va., 510 pp. General history of County. Also contains data on physiography, mineral springs, and prehistoric relics.

1917.—**Reger, David B.** The Possibility of Deep Sand Oil and Gas in the Appalachian Geo-Syncline of West Virginia. Trans. Am. Inst. of Mining and Metallurgical Engineers, Vol. LVI, pp. 856-871. A discussion of the deeper sands including a cross-section from Hinton northwestward.

1918.—**Hennen, Ray V.** Figure Showing Bituminous Coal Beds in West Virginia. W. Va. Geol. Survey. Etching.

1921.—**Reger, David B.** Carbon Ratios of Coals in West Virginia Oil Fields. Trans. Am. Inst. of Mining and Metallurgical Engineers, Vol. LXV, pp. 522-527. Discussion of carbon in coal with reference to oil and gas, including Isocarb Map of State.

1923.—Girty, George H. Observations on the Faunas of the Greenbrier Limestone and Adjacent Rocks. Tucker County Report, W. Va. Geol. Survey, pp. 450-488.

1923.—Keith, Arthur. Outlines of Appalachian Structure. Bull. Geol. Soc. America, Vol. 34, pp. 309-380. Discussion of causes of folding with statement of batholithic intrusion theory of origin, with map.

NOMENCLATURE AND CORRELATION.

In Mercer, Monroe, and Summers Counties, as in many other regions, the problem of proper nomenclature and correlation of the rocks involves a selection from equivalent titles that have been employed in different regions for the same groups of sediments. In the present instance the discrimination must be made from three generally published columns, one of which has been used in New York, Pennsylvania and other eastern States, another in Virginia and other southern Appalachian States, and a third which has been widely applied to the Mississippian Rocks in the Mississippi Valley. Most fortunately, extensive revisions of the column are not required, since there are few apparently serious mistakes in previous publications that directly refer to the territory under discussion, but many early deductions of importance need to be affirmed and many applications of local titles must be reduced to parenthetic rank so that classic names of which there is no longer a reasonable doubt may be properly applied and their evident subdivisions clearly indicated. Another task of more than passing importance has been the amplification and correlation of the rocks of the Mississippian Period, there being numerous subdivisions that have not been hitherto defined or described in any report.

In the Pennsylvanian Period, with which this Report has little to do, the nomenclature of the Second Geological Survey of Pennsylvania, as far as it is applicable, and following that the amplified Pottsville nomenclature of southern West Virginia, as applied in numerous Reports of the West Virginia Survey, is necessarily followed.

In the Mississippian Period, as will be later discussed in more detail, the necessity of choice between the distinct nomenclatures of the East and West is apparent. In this period there exist four major series in southern West Virginia,

Of these the Mauch Chunk, which comes at the top, is clearly traceable to eastern Pennsylvania where it was long ago studied and described by the geologists of that State, and it has been recognized and described as such by all the Reports of the West Virginia Survey but only vaguely so by the Folios of the United States Geological Survey which apply to southern West Virginia territory. It has also been stated in various reports that the Mauch Chunk of West Virginia corresponds in part with the Chester Series of the Mississippi Valley but the evidence for such assertions has been almost wholly lacking, since the series in West Virginia has been largely without paleontologic implication. The studies of the present Report make it possible to affirm in large part the previous deductions and furthermore to point out various direct correlations of individual strata. It is recognized that the name Chester was used by Swallow as early as 1857 while the name Mauch Chunk was not applied by Ashburner until 1877 and that the former is clearly entitled to precedence. It appears impossible at present, however, to delimit with certainty the Chester Series in West Virginia or to recognize even a majority of its subdivisions; and an even more serious obstacle is encountered in the unfortunate controversy that has arisen within the last few years concerning the relationships of its subdivisions and even of its basal limits, so that its adoption in West Virginia would be clearly imprudent. The Mauch Chunk, on the other hand, has such clear-cut boundaries from its type locality southwestward across Pennsylvania, Maryland, and West Virginia that the direct correlation of this major series and of many of its subdivisions for several hundred miles has become a certainty, even though the series is practically barren of invertebrate remains in the northeastern half of this distance.

The Greenbrier Series, coming just below the Mauch Chunk, was named in West Virginia and the title has been adopted northeastward as far as these calcareous sediments go, but southwestward and westward in the Mississippi Valley its rocks have long been known by other names. Its study is now advanced to the point that several of its subdivisions may be correlated with well-known individuals in the West,

but there are beds within its mass with a thickness of 1,000 feet in southern West Virginia and 1,700 feet in the adjoining portion of southwest Virginia, which apparently have no recorded equivalents in regions south and west of the latter State. The fact that so large a proportion of its total thickness is found only in the Virginias is sufficient reason for the permanent retention of the series name as an overriding title.

The Maccrady Series, coming just below the Greenbrier has its type locality in Smyth County, Virginia, and appears to have its geographic limits almost wholly within the boundaries of the two Virginias, so that little question of wider correlation is involved. The name Pulaski was first applied to this series but was later abandoned because of an earlier use of the same title.

The Pocono Series, coming below the Maccrady and being the basal epoch of Mississippian deposition in the eastern and southern States, is directly traceable from its type locality in northeastern Pennsylvania southwestward across Maryland, West Virginia, Virginia, and far into Tennessee. It has been known and recognized by the same title in the first three States named but in Virginia, Tennessee, Kentucky, Ohio, and elsewhere in the more western States its equivalent, or partially equivalent, beds have been known by many other titles, some of which far antedate the Pocono. As is the case with the Mauch Chunk, however, its limits are so clearly defined and its usage so firmly fixed from the Pocono Mountains to the southern boundary of West Virginia that it is believed that no title of smaller geographic application could possibly supplant it. Its relationship with some of the early groups of the typical Mississippian has been suggested and in some cases affirmed with considerable assurance but no previous statement has had more weight than that of an opinion or deduction. It is now believed that the abundant marine beds discovered by the writer in the season of 1924 and the collections made therefrom offer the positive evidence by which some of these earlier conclusions may be verified; and it should be a source of much satisfaction that this more recent information calls for no violent readjustments of previous

beliefs which were doubtless expressed with many misgivings.

The Devonian Rocks of the three counties are much attenuated both in thickness and in the number of major and minor subdivisions but fortunately the major groups that remain may be readily correlated with the classic beds of New York State, which is accordingly done; and local titles not in harmony with the standard Devonian column are herein discarded.

The Silurian Rocks, also, are much abbreviated both in thickness and in the number of major and minor subdivisions, but those that outcrop in the three counties may be definitely assigned to their proper places in the New York classification and other less deserving titles may be abandoned or reduced to parenthetic rank.

In the Ordovician Rocks a full group subdivision of the Martinsburg Series in West Virginia is afforded for the first time by the very good exposures along the northern slopes of East River Mountain and Peters Mountain and in the gap of New River between them. In this case the name Martinsburg may be properly retained as an overriding title while at the same time some of the much earlier group subdivisions within it may be expressed; and equivalent nomenclature of more recent years may be rejected. The Moccasin Limestone, which is of exclusively southern application and in which no fossils have been noted, appears to have no certain representation in the eastern column of earlier date, although Dr. Prouty has indicated (in a letter) that he considers it of Upper Chambersburg age. In view of the many differences between this formation and the typical Chambersburg, however, the southern title is retained. In the case of the pure limestone which comes beneath the Moccasin there appears to be no good reason why the name of Stones River which was applied by Safford to limestone of the same age should not be used instead of the title Chickamauga which was not employed by Hayes until 1893, and the earlier name is therefore adopted in this Report.

In the succession of dolomites which come below the Stones River Limestone and which were designated under

PLATE VI.—View of Hinton looking north across New River. Topography is made by Bluestone, Princeton, and Hinton Groups of Mauch Chunk in descending order, the furrowed slope at the right being in the abundant red shales of the latter at its type locality. Stony Gap Sandstone visible just above railroad. (Photo. by Palmer & Fowler).

the inclusive title of Knox Dolomite by Safford in 1869 and later as Shenandoah Limestone by Darton in 1892, and which are generally recognized as partly of Ordovician and partly of Cambrian age, the fact that both names include rocks of two different periods has largely caused their gradual disuse and the adoption of later and more particular groupings. In Mercer and Monroe Counties, where a maximum of about 3,500 feet of these rocks outcrop, it has been possible to establish with certainty that the upper 2,500 feet correlate with the Beekmantown Limestone so that this more precise title may be employed. In the lower 1,000 feet of the succession, however, no fossils were observed and the particular age is therefore in doubt. As previously noted, Dr. Prouty has stated (in a letter) that the formation has much the appearance of the Elbrook of Cambrian age but suggests that it be mapped with the Beekmantown until more positive evidence may be obtained, and this has accordingly been done, since it appears to be the only possible solution of the case with present data.

CLASSIFICATION OF OUTCROPPING ROCKS.

In Figure 6 will be found a general columnar section of the outcropping rocks of Mercer, Monroe, and Summers Counties, indicating the maximum and minimum thicknesses of all subdivisions of sufficient importance to be placed on the geologic maps, together with a brief description of their most salient characteristics. The further and more minute subdivisions will be exhibited under the discussions of each series in Chapters VI-XII, inclusive.

Figure 6
GENERAL COLUMNAR SECTION
OF ROCKS EXPOSED IN MERCER, MONROE AND SUMMERS COUNTIES.
(Vertical Scale; 1 inch = 1000 feet)

Era	Period	Series		Map Symbol	Section	Thickness feet.	Total feet	Description.
Quaternary	Recent			Qal		?	?	Unconsolidated Clays and gravel (River Wash)
	Pleistocene			Qal		?	?	Unconsolidated Clays and gravel, (River Terraces)
Paleozoic	Upper Carboniferous Pennsylvanian	Pottsville Series.	New River Group (Part)	Cnr		500 to 600	600	Gray massive sandstones; gray sandy or dark carbonaceous shales; coals; fresh or brackish-water fauna. Plant fossils.
			Pocahontas Group	Cp		500 to 700	1300	Gray massive sandstones; gray sandy or dark carbonaceous shales; coals; fresh or brackish water fauna; Plant fossils
	Lower Carboniferous	Mauch Chunk Series	Bluestone Group	Cbl		400 to 800	2100	Red green or variegated shales; green, gray or brown, massive or flaggy sandstones; Streaks of coal; marine and plant fossils.
			Princeton Conglomerate	Cpr		20 to 50	2150	Gray sandstone with quartz and limestone pebbles; Plant fossils.
			Hinton Group	Chn		800 to 1350	3500	Red green or variegated shales; green or gray, massive or flaggy sandstones; thin sandy limestones; streaks of coal; abundant marine fauna: Plant fossils
			Bluefield Group	Cbf.		800 to 1250	3750	Green calcareous and argillaceous fissile shales; occasional red or variegated shales; dark fissile carbonaceous shales; green or gray, massive or flaggy sandstones; limestones; coal streaks; abundant marine fauna; Plant fossils.

P.H.P.

Figure 6

GENERAL COLUMNAR SECTION
(Continued)

Era	Period	Series	Map Sym.	Section	Thickness Feet.	Total Feet	Description.
Paleozoic	Lower Carboniferous (Continued) Miss'sippian	Greenbrier	Cgr		700 to 1800	6550	Dark and siliceous limestones at top, middle and bottom; gray dove-colored, pure and slightly oolitic limestones above middle. persistent streak of white oolite with red shale below middle; abundant black chert in lower 350 feet, lentiocular carbonaceous shales; abundant marine fauna; two or more plant fossil zones.
		Maccrady	Cmcc		25 to 350	6900	Deep red, purple, argillaceous or yellow, calcareous or sandy shales, yellow earthy ls; calcareous ss; sparse marine fauna.
		Pocono	Cpo		250 to 900	7800	Gray massive or cross-bedded sandstones with frequent quartz pebbles; one persistent reddish-brown ss; gray sandy or dark carbonaceous shales. impure semi-anthracitic coals; marine fauna abundant land plants; also fucoids.
	Upper Devonian	Chemung	Dch		500 to 1600	9400	Olive-green flaggy fine-grained sandstones, interlaminated with olive-green sandy or argillaceous shales; conglomerate near top with quartz pebbles; several zones of marine fauna, principally in sandstones.
		Portage	Dp		400 to 1600	11000	Greenish-gray, sandy or argillaceous shales; interlaminated with greenish-gray flaggy, fine grained sandstones; no marine fossils observed.

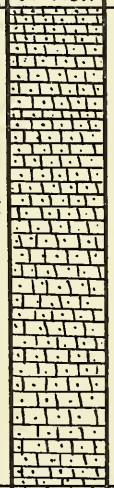
RHR

Figure 6

GENERAL COLUMNAR SECTION
(Continued)

Era	Period	Series	Map Sym.	Section	Thickness Feet	Total Feet	Description.
Paleozoic.	U.D. Dev.	Genesee	Dg		50 to 100	11100	Black fissile Slaty Shale; Occasional marine fossils.
	Middle Devonian	Hamilton	Dhm		0 to 500	11600	Green argillaceous or sandy Shale; marine fauna.
		Marcellus	Dm		100 to 300	11900	Black carbonaceous, fissile lustrous Shale; marine fauna.
	Lower Dev.	Oriskany	Do		50 to 150	12050	Brown Massive, coarse ferruginous SS. Sparse marine fauna.
		Helderberg	Dhl		0 to 50	12100	Cherty limestone; marine fauna.
	Silurian.	Clinton	Scl		300 to 500	12600	Yellowish-green or reddish-brown, sandy or ferruginous Shales; heavy White quartzite, and ferruginous SS. iron ore; manganese; Medina fauna.
		White Medina	Swm		50 to 150	12750	White massive sandstone, with quartz pebbles; arthrophycus.
		Red Medina	Srm		300 to 400	13150	Red massive and current-bedded, Or flaggy Sandstones; red and green Shales; sparse marine fauna; arthrophycus.
		Gray Medina	Sgm		2 to 0	13160	Gray SS; no fossils observed.
	Ordovician	Mohawkian Series — Lower. Mayesville Group.	Oms		300 to 350	13500	Brown friable Sandstone; brown Sandy Shale; abundant marine fauna.
		Mohawkian Series — Eden Group	Oms		400 to 450	13950	Yellow argillaceous or Sandy Shales; thin-bedded crystalline limestones; abundant marine fauna.
		Mohawkian Series — Trenton Group	Oms		600 to 750	14700	Blue thin-bedded Crystalline limestones interlaminated with calcareous Shales; abundant marine fauna.
		Moccasin	Omc		450 to 900	15100	Red earthy irregularly-bedded limestones; no fossils observed.
		Stones River (Chickamauga)	Osr		500 to 700	15800	Massive limestone, dove-colored in upper portion but dark, crystalline and carrying, black Chert toward base; marine fauna.

Figure 6
GENERAL COLUMNAR SECTION
(Concluded)

Era	Period	Series	Map Sym.	Section	Thickness Feet	Total Feet	Description
Paleozoic	Ordovician (Continued)	Beekmantown	Obk		2000 to 2500	18300	Principally gray massive dolomite; gray chert in top which contains marine fauna and weathers to fine particles; black chert in upper portion of series; gray chert in middle and lower portion, apparently in stratified but indistinct zones. Weathering to rectangular or irregular blocks, partly chalcedonic and containing Cryptozoon and partly weathering to scoriaceous or cauliflower shapes with marine fauna; no fossils observed in matrix.
	Cambrian?	Probably Elbrook but mapped as Beekmantown for lack of evidence	Obk		700 to 1000	19300	Gray or yellowish-buff dolomite. (with tinges of red) in massive ledges interstratified with gray or yellowish-buff shales; contains much bedded gray chert, which weathers to rectangular blocks; no fossils observed.

PHP

CHAPTER IV.

STRUCTURE.

METHODS OF GEOLOGIC WORK AND REPRESENTATION OF STRUCTURE.

In determining the structure, or lay, of the rocks in Mercer, Monroe, and Summers Counties the same method of geologic work may not be applied with good results to the entire area. In all of Summers and in that portion of Mercer northwest of Stony Ridge and that part of Monroe northwest of Chimney Ridge (near Peterstown) and Swoopes Knobs (near Union) where the rocks have been only slightly disturbed, and where the original strata are still approximately horizontal, there are numerous well-defined, undistorted, and easily recognized beds, so that it is possible to measure thicknesses and determine dips over wide areas with as much exactitude and precision as circumstances may require, accuracy being limited mainly by the amount of time consumed and the instrumental methods employed.

In this region careful structure maps have been made, showing the position of the base of the **Avis Limestone** of the Hinton Group of the Mauch Chunk Series, this stratum being about 40 feet thick and so distinct in appearance from other beds within several hundred feet above and below that it can scarcely be mistaken. By this means the elevation of its base above sea-level is shown by **green structure contours** on Maps II, IV, and VI, and inasmuch as all other horizons lie approximately parallel to it the contours on this limestone can be used to determine the position of any other stratum. The Avis Limestone outcrops over a considerable portion of Summers County and in northern Mercer where the deep valleys

of New River and its major tributaries afford a good opportunity to determine its interval from other strata by direct vertical measurement. In all this region careful sections were measured at frequent localities, the aneroid and hand-level being used to determine intervals, so that the structure could be projected farther west where the Avis Limestone is beneath drainage and farther southeast where its horizon is above the topography.

In the southeastern parts of Mercer and Monroe Counties, where orogenic disturbance has been comparatively severe, entirely different methods of stratigraphic work were required. In this portion of the two counties the rocks have been greatly tilted, being vertical in some localities and elsewhere faulted and duplicated and in some cases overturned for long distances. Under such conditions the aneroid or level becomes of small value, the combination clinometer and pocket transit taking their place. By the use of the topographic maps, on which localities may be readily plotted at a glance, it was possible to make a great number of cross-sections across the dips, and to record accurately the contact lines of the different series. Several of these cross-sections have been plotted to scale and appear on the margins of Maps II and IV. In various localities also, where conditions were favorable, horizontal measurements were made across the dips to secure data for the computation of thicknesses by trigonometric methods, and the resulting sections, together with those vertically measured in the more northern region, appear in Chapter V under the subject of "Measured Sections".

DETAILED STRUCTURE.

GENERAL FEATURES.

As mentioned above, the region embracing Summers County and the adjacent northern portion of Mercer and the northwestern part of Monroe is an area of gentle and rather symmetrical folds, of comparatively slight disturbance, and as a whole may be considered as one broad monocline in which minor structural relief has developed, being a continuation of the same conditions which generally prevail from the Ap-

palachian Geosyncline in the western part of the State southeastward to the region where the Allegheny Ridges begin. From the basin mentioned to the southern end of Summers County, a distance of about one hundred miles, the rocks have remained nearly horizontal through the agency of competent strata, capable of resisting in large measure the force of lateral thrust, there being many heavy sandstones of great compressive strength in the Pennsylvanian Rocks which cover the surface for many miles as well as in the Pocono Series farther down, while the intermediate Greenbrier Series is itself capable of much resistance.

In the southern edge of Mercer and the southeastern portion of Monroe severe folding has occurred in the Mississippian, Devonian, and older rocks which lie beneath, due in part perhaps to somewhat incompetent strata but probably more to the evident proximity of the force that caused the lateral thrusts. The violent folding of this region has brought to the tops of the mountains Silurian Rocks which lie deeply buried in regions farther west, and the Pennsylvanian strata are entirely absent. Whether these younger strata once covered this area is a question on which no definite conclusion may be reached, but their complete absence in all the deep basins to the southward is evidence for the belief that their southern boundary may have been north of East River Mountain and Peters Mountain.

In Monroe County east of an approximate north and south line between Alderson and Lindside a change of much more than local significance takes place in the structural position of the rocks. Southwest of this meridian the general course of the Appalachian System, through the remainder of West Virginia and southwest Virginia, and of its attendant minor folds in the northwestern foot-hills, is approximately North 70 degrees East, or South 70 degrees West. To the eastward and northeastward through eastern West Virginia, northern Virginia, and southern Pennsylvania their prevailing trend is North 30 degrees East, or South 30 degrees West. The theory has been advanced by Keith[1] that this fundamental

[1]Arthur Keith, Outlines of Appalachian Structure, Bull. Geol. Soc. Am., Vol. 34, pp. 309-380; June, 1923.

change in the strike of the mountain system is caused by the extrusion of a great mass of granite batholiths in North Carolina, South Carolina, and Georgia, the strata of the southern States having been pushed northward by a differential intensity of lateral thrust corresponding to the change in mountain alignment, and to the writer the explanation is more satisfactory than any previous hypothesis.

In Monroe County the local developments at this change of strike are most interesting. West of the line between Alderson and Lindside the foot-hill folds in Monroe and Mercer Counties are few in number and approximately parallel to Peters Mountain, East River Mountain and other great ranges farther south. East of this line in Monroe and southern Greenbrier Counties the foot-hill anticlines turn sharply toward the north, as indicated on Map IV, their direction being approximately the same as the general Appalachian strike in northern West Virginia and southern Pennsylvania, and the folds at the same time become much more numerous. The courses of Little, Gap, Peters, Potts and others of the more massive mountains, however, remain much the same as in the southern States for 20 miles east of the meridian mentioned and make their general turn to the northward only at the extreme eastern edge of Monroe County, so that through this 20-mile sector the minor folds point toward the main mountains at an oblique angle No explanation of these attendant phenomena is herein offered, the subject being one that should have a more extended study before an expression of opinion.

ANTICLINES AND SYNCLINES.

In the three counties there are numerous anticlines, or arches, in the structure where the rocks bend upward, and also there are corresponding synclines, or basins, where the rocks bend downward in the geographic zones between the anticlines. In all of Summers County and in the northern portion of Mercer and the northwestern part of Monroe the anticlines and synclines are comparatively gentle and seldom have much reflection in the topography, but in southern Mercer and southeastern Monroe they become bold features which largely control the direction, shape, and height of the moun-

tains. These folds will be described by counties in the order in which the three counties are treated in this Report.

Anticlines and Synclines, Mercer County.

Dry Fork Anticline.—The Dry Fork Anticline of White,[2] which touches only the western edge of Mercer County, appears to be an offshoot, or branch, of the more violent Abbs Valley Anticline. Although not a long fold it passes through several counties of two States and in addition to the original citation has been described in these areas by various writers,[3] but no description in its entirety is afforded. As now completely mapped, this arch starts in Mercer County, West Virginia, near the Pinnacle Rock, approximately one mile east of Simmons. From this locality it passes westward across Bluestone River at Simmons and three and one-half miles from its beginning crosses the Mercer County line into Tazewell County, Virginia. In Tazewell County its length is only one mile, its direction still being westward and its position near the head of Coal Run and near the northernmost tip of the county. It then enters McDowell County, West Virginia, and turns southwestward, crossing Tug Fork at O'Toole, South Fork at Milam Branch, Big Creek one mile below and northwest of Squirejim, Jacob Creek one-fourth mile above and southeast of Squire, Dry Fork just above and south of Beech Fork, and passes into Tazewell County, Virginia, again 1.3 miles southwest of Beech Fork, its total length in McDowell being 17½ miles. This second sector in Tazewell County is 14 miles long, the direction of the axis being still southwestward but more nearly westward than in McDowell, Indian Creek being crossed one mile above and north of

[2]I. C. White, Vol. II(A), W Va. Geol. Survey, pp. 19-20; 1908.

[3]Ray V. Hennen, Wyoming and McDowell County Report, W. Va. Geol. Survey, pp. 41-42; 1915. C. E. Krebs, Raleigh County and Western Portions of Mercer and Summers Counties Report, W. Va. Geol. Survey, p. 49; 1916. T. K. Harnsberger, The Geology and Coal Resources of the Coal-bearing Portion of Tazewell County, Virginia, Bull. XIX, Va. Geol. Survey, p. 30; 1919. C. K. Wentworth, The Geology and Coal Resources of Russell County, Virginia, Bull. XXII, Va. Geol. Survey, p. 31; 1922. Henry Hinds, The Geology and Coal Resources of Buchanan County, Virginia, Bull. XVIII, Va. Geol. Survey, p. 55; 1918.

Harman, Big Creek one-half mile below and south of Coaldan, and the Tazewell-Russell County line 2.3 miles northwest of Red Ash. In Russell County, Virginia, its course is somewhat tortuous but generally southwestward for seven miles and it passes into Buchanan County, Virginia, one mile west of Drill. In the latter county it continues southwestward three miles to the vicinity of Council, where it ends on the waters of Russell Fork within half a mile of the faulted zone that is indicated as approximately parallel to Russell Fork and nearly at right angles to the axis of the anticline.

The entire length of the anticline as mapped in the two States is 32 miles. In Mercer County it is fairly symmetrical about its axis but there is an extremely rapid plunge southwestward along the crest, the elevation of the Avis Limestone horizon at the Pinnacle being about 4,000 feet while at the Tazewell County line it is only 1,250 feet, making a total decline of 2,750 feet in 3½ miles or at the rate of 785 feet per mile, most of which occurs in the first two miles. In the northern tip of Tazewell County there is a saddle, the Avis Limestone being less than 1,250 feet above sea-level and the No. 3 Pocahontas Coal less than 2,450 feet. In McDowell County it is quite symmetrical about its axis but it rises gently to an elongated dome 3½ miles southwest of O'Toole, the No. 3 Pocahontas being 2,600 feet above sea-level. Beyond this dome it descends at the rate of 60 feet per mile to the second sector of its course in Tazewell County, the elevation of the No. 3 Pocahontas at the State line being 2,000 feet. In Tazewell County the fold still remains symmetrical and the axis continues to descend southwestward, the elevation of the Raven Coal at the McDowell County line being 3,750 feet while at the Russell County line it is less than 2,350, making a plunge of 1,400 feet or at the rate of 100 feet per mile. In Russell County the symmetry continues and also the descent along the axis, the elevation of the Raven Coal at the Buchanan County line being only 2,000 feet, making a rate of 43 feet per mile. In the latter county the same conditions still prevail, the descent as contoured on the Splash Dam Coal being 100 feet in three miles or at the rate of 33 feet per

mile and the elevation of this coal at the southwestern end of the fold being 2,550 feet.

In Virginia the surface geology along the axis is entirely that of the Pottsville Series of the Pennsylvanian, but in McDowell County, West Virginia, the outcrops are partly Pottsville and partly Mauch Chunk, the latter series of the Mississippian being above drainage along some of the principal streams. In Mercer County the Pocahontas Group of the Pottsville covers the anticline mainly in the sector between the Tazewell County line and Bluestone River, but east of the river the Mauch Chunk is above drainage, the Bluestone, Princeton, Hinton, and Bluefield Groups being all successively brought above drainage.

Pocahontas Syncline.—The Pocahontas Syncline of Harnsberger[4] is a narrow and rather sharp basin described and mapped as beginning in Tazewell County, Virginia, on the waters of Laurel Creek 4½ miles southwest of Boissevain. From this point is extends northeastward 8 miles through Tazewell County, its axis being one-half mile northwest of Boissevain and just at the northwestern edge of Pocahontas. About one mile north of Pocahontas it enters Mercer County, West Virginia, and continuing its northeastward direction, passes just east of Coopers and Bramwell and ends in the angle between the Dry Fork Anticline and Boissevain Fault just south of Simmons, its length in this county being two miles. Throughout its total length of only 10 miles this basin is seldom more than one-half mile distant from and northwest of the Boissevain Fault, there being evidence that it has been completely obliterated at its southwestern end by this more violent disturbance so that its original further extent may only be conjectured. In its visible length there is a continual rise northeastward along the axis, the total being 900 feet in 10 miles or at the rate of 90 feet per mile. Near the immediate axis the contours are symmetrical but on the southeast side they soon pass into the fault while on the northwest they rise gently toward the Dry Fork Anticline.

[4]T. K. Harnsberger, The Geology and Coal Resources of the Coal-bearing Portion of Tazewell County, Virginia, Bull. XIX, Va. Geol. Survey, p. 37; 1919.

The surface geology in Virginia is entirely that of the Pottsville Series but in Mercer County these rocks cover only the ridge tops along the axis, the Bluestone Group of the Mauch Chunk being exposed in the lower topography.

Dunn Anticline.—The Dunn Anticline, which has not been previously named or described, is a comparatively low arch originating in the vicinity of Nubbin Ridge, Mercer County, about two miles northwest of Spanishburg. From this locality it extends northeastward, crossing Camp Creek at the mouth of Meadow Branch, Mountain Creek one-half mile west of Dunn, and the Mercer-Summers County line one mile northeast of Dunn, its length in the former county being 9 miles. In Summers County it continues northeastward for 16 miles, passing through Ellison, crossing Bluestone River one-half mile above and east of Suck Creek and New River 1¼ miles above and south of Hinton or three-fourths mile below and northwest of Bellepoint, and finally ending against a long monocline 4 miles northeast of Hinton and one mile east of Stonelick Knob.

Throughout its length this arch is fairly symmetrical about its immediate axis, but on the northwest there is a long monocline while on the southeast the dip soon reverses in a shallow basin. At its beginning in Nubbin Ridge the Avis Limestone has an elevation of 1,650 feet and from this point there is a northeastward rise along the axis for 17 miles to the head of Surveyor Branch in Summers County where there is a low dome, the total rise in this distance being 450 feet, or at the rate of 27 feet per mile. The axis then descends about 50 feet to a saddle just northeast of New River but rises to a small dome or nose just southeast of Stonelick Knob, the elevation of the Avis Limestone being 2,200 feet. Its northeastern end has the appearance of a gentle saddle or terrace which merges into the monocline. The surface geology in both counties is that of the Mauch Chunk Series, there being full exposures of the Bluestone, Princeton, and Hinton Groups, while only the top of the Bluefield Group is visible along the deep valley of New River.

Bellepoint Syncline.—The Bellepoint Syncline, which has not been previously named or described, is a shallow reversal

of the long monoclinal dip that is the prevailing feature in northern Mercer and in the most of Summers County. This basin originates near the head of Grassy Branch, two miles southwest of Spanishburg, Mercer County, and extends northeastward, crossing Camp Creek 0.8 mile northwest of Eads Mill, Laurel Creek one mile above and northwest of its mouth, Mountain Creek one-half mile above and west of its mouth, and the Summers County line 0.3 mile northwest of the mouth of Mountain Creek. In Summers County it continues northeastward for 15 miles, crossing the meanders of Bluestone River three times in the first two miles and then, following slightly east of this stream for six miles, again crosses it 0.6 mile above and west of its mouth. Three miles farther on it crosses New River, then passes just southeast of Bellepoint, crosses Greenbrier River 0.7 mile above and east of its mouth, and finally ends against the monocline in the vicinity of Crawford School on Big Creek.

Throughout its length in Mercer County this basin is fairly symmetrical about its axis but in Summers County the rise on the northwest side is slightly faster than on the southeast. There appears to be an elongated closing basin in the vicinity of Spanishburg and Camp Creek, Mercer County, but from the latter stream northeastward to the end of the structure there is a continued but irregular rise. At Camp Creek the elevation of the Avis Limestone is less than 1,600 feet and at Crawford School, Summers County, it is 2,150 feet, making a total rise of 550 feet in 16 miles or at the rate of 34 feet per mile. The surface geology along the axis is that of the Bluestone, Princeton, and Hinton Groups of the Mauch Chunk Series, there being apparently no outcrop of the Bluefield.

Abbs Valley Anticline.—The Abbs Valley Anticline of Campbell[5] is a large and important arch that extends entirely across central Mercer County and the extreme southern end of Summers and almost across Monroe, there being a gradual northeastward decrease in the intensity of the folding so that it finally disappears. Its original southwestern end, which

[5]M. R. Campbell, Pocahontas Folio, No. 26, U. S. Geol. Survey; 1896.

was apparently somewhere in southwest Virginia, has now been completely obliterated by overthrust faulting, so that in the vicinity of Cedar Bluff and Richlands, Adria and Phillips (or Billips?) School in Tazewell County there remains only the southeastern limb of the fold,[6] and the arch itself appears to be now represented by the Richlands Fault which has taken its place. This fault has been mapped by Harnsberger to the Tazewell-Russell County line in the vicinity of Raven. Beyond this point the Hunter Valley Fault of Stevenson[7] has now been mapped in detail through Russell County by Wentworth,[8] and on through Scott County by Eby.[9],The latter writer is authority for the statement that the fault is 370 miles long and extends from "Near Rome, Georgia, to New River, Virginia," its stratigraphic displacement in eastern Wise County being 15,000 feet. The fault, however, never reaches New River, since it becomes an anticline before passing out of Tazewell County.

Considering the Hunter Valley (Richlands) Fault in its relationship to the Abbs Valley Anticline in West Virginia, which is the main reason for its discussion at this point, it is apparent from the maps of Harnsberger in Tazewell County that the Richlands Fault is a southwestward extension and replacement of the anticline. At the Tazewell-Russell County line the maps of Wentworth indicate the southwestward extension of this fault across the latter county, its alignment being quite irregular at the northeastern end of the county and this sector being indicated without a name on the map. Its correspondence with the Richlands Fault at the Tazewell County line is evident, however, from the maps of the two counties, and with the exception of the uncertainty introduced

[6]See M. R. Campbell, Tazewell Folio, No. 44, U. S. Geol. Survey; 1897; and T. K. Harnsberger, The Geology and Coal Resources of the Coal-bearing Portion of Tazewell County, Virginia, Bull. XIX, Va. Geol. Survey, Fig. 6, p. 40; 1919.

[7]John J. Stevenson, A Geological Reconnaissance of Parts of Wise, Lee, and Scott Counties, Va.; Proc. Am. Phil. Soc., Vol. XIX, pp. 219-262; 1881.

[8]C. K. Wentworth, The Geology and Coal Resources of Russell County, Virginia; Bull. XXII, Va. Geological Survey; 1922.

[9]J. Brian Eby, The Geology and Mineral Resources of Wise County and the Coal-bearing Portion of Scott County, Virginia, Bull. XXIV, Va. Geol. Survey, pp. 137-138; 1923.

by the irregular course of the fault in northeastern Russell, which may have been largely due to differential overthrust followed by differential erosion, its identity appears to be defined as passing just northwest of Big A Mountain, just northwest of Clinchfield, both in Russell County, and just northwest of St. Paul, Wise County. In Scott County the maps of Eby show it as passing a mile northwest of Dungannon, a half mile south of Ka, and approximately through Mabe and Horton Summit; and its further southwestward extent is shown on various other maps.

Returning now toward West Virginia the structure loses its character as a fault and becomes distinctly anticlinal near the head of Abbs Valley southeast of Smith Store, Tazewell County, and so continues northeastward through this valley to the West Virginia line, there being an apparently elongated dome in this sector with its apex near the cross-roads a mile or so south of Pocahontas, with more than half (1110 feet) of the Greenbrier Series exposed.

The anticline enters Mercer County, West Virginia, 0.6 mile northwest of Flattop Yards and preserves a northeastward course entirely through the county, crossing Bluestone River one-third mile northwest of Nemours village, passing about the same distance southeast of the Pinnacle, crossing Sandlick Creek 0.7 mile north of Sandlick village and then closely following the ridge of Blackoak Mountain to its northeastern end. Here is crosses Brush Creek at Gardner Junction and farther on crosses Laurel Creek 1.3 miles south of Athens, passes 1.2 miles south of Pettry and one-fourth mile north of Parish Hill School, and reaches the Summers County line 1.2 miles northwest of the mouth of Roundbottom Creek, its length across Mercer County being 27 miles.

In Summers County the arch passes across only the extreme southern corner for a distance of two miles, its axis being only one mile north of the common corner of Mercer, Summers, and Giles Counties. One-half mile above and south of Wylie Island it crosses New River and one-fourth mile beyond the river it reaches the Monroe County line.

In Monroe County the course of the arch continues northeastward without much change for 11 miles to Greenville,

PLATE VII.—Princeton Sandstone at brow of Tallery Mountain 2¼ miles south of True, Summers County, looking northward. Body of ledge is just beyond fallen tree, a front view being impossible on account of steep slope of mountain. (Photo by Palmer & Fowler).

passing just south of Chestnut Hill (Bozoo) and through Ballard, crossing Hands Creek one-fourth mile above and east of Hands Creek School and Indian Creek one-half mile southeast of Greenville. Here it veers considerably more toward the north and so continues for 10 miles, passing 1.1 miles northwest of Sarton, one-fourth mile east of Johnson Crossroads and finally ending in a monocline 1.3 miles east of Wolf Creek Post-office.

This anticline is fairly symmetrical about its axis through all its course in West Virginia but in Tazewell County, Virginia, its western side becomes rapidly steeper until it finally overturns and eventually becomes the Richlands overthrust. In Mercer County it descends to a saddle on Laurel Creek south of Athens, the elevation of the Avis Limestone at that point being only 2,300 feet as compared to more than 5,000 feet at the Mercer-Tazewell line, making a total decline of 2,700 feet in 18 miles, or at the rate of 150 feet per mile. In the Pinnacle and Blackoak Mountain region it is a bold feature along which the rocks stand nearly vertical. From Laurel Creek the axis then rises northeastward for 11 miles to an elongated dome at Chestnut Hill (Bozoo), Monroe County, where the Avis Limestone horizon is 2,850 feet above sea-level, making the rise in this sector at the rate of 50 feet per mile. At Ballard, 2½ miles northeast of Chestnut Hill there is another saddle, the descent from Chestnut Hill being at the rate of about 40 feet per mile. Northeast of Ballard there is a continuous but irregular rise for 13 miles to Johnson Crossroads, Monroe County, the elevation of the Avis Limestone horizon at this latter point being 4,500 feet as compared to less than 2,800 feet at Ballard and making an average rise of 130 feet per mile. From Johnson Crossroads the axis then descends for four miles to the end of the arch, the Avis Limestone horizon at the latter locality being 3,700 feet, making the rate of dip along this sector 200 feet per mile.

From the Tazewell County line for seven miles northeastward there is a narrow outcrop of Greenbrier Series along the axis, followed for another four miles by the Bluefield Group of the Mauch Chunk Series, after which the Hinton Group of the latter forms the surface almost to the Summers

County line. In Summers County and the adjoining edges of Mercer and Monroe there is an outcrop of the Bluefield Group in the New River Valley. In Monroe County between the Summers line and Ballard the outcrop is mainly the lower portion of the Hinton Group with some Bluefield along Stinking Lick Creek. Northeast of Ballard the Bluefield forms the surface all the way to the eastern side of Ellison Ridge with the exception of a short sector along Hands Creek where the top of the Greenbrier is above drainage. Beyond Ellison Ridge the Greenbrier again comes to the surface in the valley of Cooks Run and Indian Creek in the vicinity of Greenville but there is a further outcrop of Bluefield in a high cross ridge three miles north of Greenville. Beyond this ridge the Greenbrier outcrop is continuous to the end of the fold, after which the Bluefield is again preserved.

Hurricane Ridge Syncline.—The Hurricane Ridge Syncline of Campbell[10] is a long, deep basin which extends entirely across Mercer and Monroe Counties. It apparently originates in southwest Virginia, approximately at the Russell-Tazewell County line, three miles southwest of Richlands and then extends northeastward passing a little northwest of Baptist Valley village and later following quite closely the valley of Mud Fork of Bluestone River to the West Virginia line, its length in Virginia being about 35 miles.

In West Virginia this fold enters Mercer County 1½ miles eastward from Falls Mills, and extends northeastward, passing through Hurricane Ridge from which it secures its name, crossing Brush Creek and the Bluefield-Princeton road half-way between Ceres and El Centro Stops, crossing the Virginian Railway 3½ miles south of Princeton and continuing in the same general direction for two miles farther. One mile south of Stinson School it turns sharply southeastward for two miles but on the head of Fivemile Creek it again resumes its northeastward direction which is thereafter maintained to the northern boundary of Monroe County. In eastern Mercer County it passes one-half mile north of Goodwyn Chapel, crosses Christian Ridge at New Zion School, and enters Giles County,

[10]M. R. Campbell, Pocahontas Folio, No. 26, U. S. Geol. Survey; 1896.

Virgina, one mile northwest of Glenlyn, its total length in Mercer County being 22 miles.

In Giles County, which makes a northward wedge between Mercer and Monroe, this syncline crosses New River one mile northwest of Glenlyn, passes northeastward and again tips a bend of the river one-half mile northeast of Lurich, passes through the southern end of Wylie Mountain and reaches the Monroe County line at Peterstown, its length in Giles County being 5 miles.

In Monroe County it follows closely with the valleys of Rich Creek and Mud Run, crosses the head of Blue Lick Creek 0.8 mile northwest of Lindside, crosses Hands Creek at Coulter Chapel School, passes approximately through the mouth of Rock Camp Creek just south of Raines Corner, follows slightly southeast of Indian Creek to a point one-half mile east of Salt Sulphur Springs where it crosses to the western side of the creek, passes on through the submerged valley of this stream one-half mile west of Union, extends on through the sinks, passing one-fourth mile southeast of Pickaway and the same distance southeast of Monitor, reaching Second Creek one-third mile northwest of and below Second Creek village, and crossing the Monroe-Greenbrier County line 1½ miles southeast of Organ Cave, beyond which it has not been traced. The length of this basin across Monroe County is 30 miles, making its total length in Virginia and West Virginia, as now mapped, 92 miles.

This basin is generally asymmetrical, the rise on the northwestward side being normal and usually gentle, but becoming steep and often overturned on the southeastern limb. This overturn continues through Tazewell, Mercer, and Giles Counties and into Monroe to the vicinity of Turkey Creek three miles southwest of Union where the dip becomes normal and so continues to the Greenbrier line, the basin becoming gradually more shallow in this latter sector and being somewhat obscure in the vicinity of Second Creek and the Monroe-Greenbrier line.

From its origin in Virginia the axis of this syncline gradually sinks northeastward apparently through all its extent in that State and also in Mercer County until a low area

is reached along Brush Creek two miles northeast of Stony Gap, the Avis Limestone at this point being only 1,550 feet above sea-level as compared to more than 1,750 feet at the Virginia line and an unknown but much greater elevation in western Tazewell, and the pitch from the Virginia line to this low area being at the rate of 25 feet per mile. From this area the axis rises northeastward for 2½ miles and forms a saddle in the sector just north of Billie, the Avis Limestone being 1,650 feet above sea-level. Beyond this locality the structure descends for two miles to the point where it crosses the Virginian Railway which appears to be the lowest depth in the entire basin as herein delineated, the elevation of the Avis Limestone being only 1,400 feet. From the bottom of this depression the structure then rises northeastward for 33 miles to Turkey Creek, three miles southwest of Union, Monroe County, beyond which contours have not been plotted. At Turkey Creek the elevation of the Avis Limestone horizon is 3,300 feet, making a total rise of 1,900 feet or at the rate of 57 feet per mile. At the Greenbrier County line the Avis horizon would have an elevation of about 4,200 feet, making an additional northeastward rise of 900 feet in the 13 miles of this sector, or at the rate of 70 feet per mile.

The outcrops along this basin are all of Mississippian age. At the southwestern end in Tazewell County the Greenbrier Series is mapped as the surface formation but slightly northeast of Baptist Valley the deepening structure holds the Bluefield Group of the Mauch Chunk Series followed in turn by the Hinton Group; and farther northeast in the vicinity of the head of Mud Fork the Princeton Conglomerate crosses the basin and is soon succeeded by the Bluestone Group which continues as the surface outcrop all the way down Mud Fork to the West Virginia line. In Mercer County the Bluestone outcrop continues to Fivemile Creek, the principal thickness of this group being exhibited in Hurricane and Big Ridges and only the upper portion being eroded. On Fivemile Creek the ascending structure and the deeper valleys bring the Princeton and Hinton Groups to the surface, the former soon passing above the topography and the latter remaining as the axial outcrop across eastern Mercer and Giles Counties and

into Monroe County as far as Lick Run slightly west of Rock Camp village. Between Lick Run and Rock Camp Creek the Hinton Group occurs only in the higher topography, the Bluefield being above drainage in the valleys, and beyond Rock Camp Creek only the Bluefield remains, its outcrop being continuous almost to Salt Sulphur Springs. On Indian Creek just east of Salt Sulphur Springs the Greenbrier Series comes above drainage and remains as the outcrop through Union, Pickaway, Monitor, and across the valley of Second Creek nearly to the Greenbrier County line, the last 1½ miles along the axis in Monroe County being made by the Maccrady Series.

Anticlines and Synclines, Monroe County.

Alderson Anticline.—The Alderson Anticline, not previously named or described, is a moderate fold situated in the extreme northwestern corner of Monroe and the eastern edge of Summers County. Beginning just east of Bargers Springs in the latter county, it extends northeastward across Wind and Kelly Creeks 5½ miles to the Monroe County line one-half mile southeast of Riffe, and passing into this county it crosses Wolf Creek one-third mile above its mouth and reaches the Greenbrier River and the Greenbrier County line at Alderson, its length in Monroe County being 4½ miles and its total length as now mapped 10 miles. Its further extent in Greenbrier County has not been mapped.

Throughout its length in the two counties this arch is fairly symmetrical about its axis but the structure has a continuous although irregular northeastward rise toward Greenbrier County, the elevation of the Avis Limestone horizon at the southern end being 2,500 feet as compared to more than 3,400 feet at Alderson, making its average rise 90 feet per mile. The surface geology is principally that of the Bluefield Group of the Mauch Chunk Series, there being Greenbrier outcrops on Wind, Kelly, and Wolf Creeks and along the Greenbrier River at Alderson.

Creamery Syncline.—The Creamery Syncline, not previously named or described, is a well-marked basin occurring a

few miles east of the Alderson Anticline. Starting in Summers County on Stony Creek one mile southeast of Bargers Springs it extends northeastward and crosses into Monroe only one-half mile from its beginning. In the latter county it continues with the same course and approximately with the valley of Stony Creek 3½ miles, and then turns more toward the north, crossing the head of Wind Creek, reaching Kelly Creek just east of Creamery and passing up Flint Hollow and then diagonally across Wolf Creek Mountain, crossing Wolf Creek just southwest of Trinity Church, and finally reaching the Greenbrier River and the Greenbrier County line slightly less than one mile east of Alderson, its length in Monroe being 10½ miles and its total length in the two counties 11 miles. Its further extent in Greenbrier County has not been mapped.

Throughout its length this basin is quite symmetrical about its axis but there is variation in its depth. From its beginning there is a slight descent to a low point on Stony Creek south of Lively School, the elevation of the Avis Limestone horizon here being 2,400 feet. From this locality northeastward for six miles to Wolf Creek there is a rise of 900 feet, making an average of 150 feet per mile, but northeast of Wolf Creek and Trinity Church the axis appears to be approximately level to the Greenbrier River, this part of the fold being shallow and scarcely perceptible. At its southwestern end the surface outcrop is the Bluefield Group and this is the principal formation along its length, there being remnants of the Hinton Group in the hills south and northeast of Lively School and in the summit of Wolf Creek Mountain, and the top of the Greenbrier Series being exposed on Wolf Creek and its tributaries and in the valley of Greenbrier River.

Mt. Pleasant Anticline.—The Mt. Pleasant Anticline, not previously named or described, is a weak fold that starts 1½ miles northwest of Wolf Creek Post-office, and extending almost northward and passing just east of Mt. Pleasant School, reaches the Greenbrier River and the Greenbrier County line 1½ miles east of Alderson, its total length in the county being barely four miles. Its further extent in Green-

brier County has not been mapped. Its surface geology is mainly that of the Bluefield Group of the Mauch Chunk Series, there being outcrops of the Greenbrier Series in the low topography at its southern end in the Wolf Creek Valley and also in the deep gorge of the Greenbrier River. One mile south of Mt. Pleasant School there is a slight dome, the elevation of the Avis Limestone horizon being 3,700 feet.

Laurel Creek Syncline.—The Laurel Creek Syncline, not previously named or described, is a readily visible depression lying about one mile east of the Mt. Pleasant Anticline and starting one mile north of Wolf Creek post-office. Its course from this point is slightly east of north and up the valley of Laurel Creek to the head of this stream and into Greenbrier County two miles east of Alderson, beyond which it has not been mapped, its length as indicated being three miles. The rise is much the same on either side of the axis but the basin lies much nearer to the Mt. Pleasant Anticline on the west than to the Sinks Grove Anticline on the east. Throughout its length there is a slight northward plunge. Its surface geology is mainly that of the Bluefield Group of the Mauch Chunk Series, there being outcrops of the Greenbrier Series at the southern end and in the deep valley of Greenbrier River along the Monroe-Greenbrier County line.

Abbs Valley Anticline.—The Abbs Valley Anticline, which is a prominent structural feature in western Monroe, has already been described, pages 142-146.

Knobs Syncline.—The Knobs Syncline, not previously named or described, is a short, but well-marked basin lying east of the Abbs Valley Anticline and having its whole length within Monroe County. Starting on Back Creek, 0.6 mile east of Lillydale, this depression for its first 3½ miles has a course slightly west of north, Laurel Creek being crossed about midway along this sector. At Brown School, however, it turns to a course slightly east of north and so continues for 4½ miles, passing one mile west of Knobs village and just west of Reynolds School and crossing Broad Run two miles southeast of Wolf Creek Post-office and ending against the southern end of Flattop Mountain just beyond Broad Run. The fold is quite symmetrical about its axis in

its whole length of eight miles but there is much variation in its depth. At its southern end the elevation of the Avis Limestone horizon is only 3,600 feet while at Brown School it has risen to 4,300 feet, making the average 200 feet per mile. From Brown School the axis is then approximately level for 2½ miles after which it descends 600 feet in 2½ miles or at the rate of 240 feet per mile. The surface geology is mainly that of the Bluefield Group of the Mauch Chunk Series, there being a brief outcrop of Greenbrier in a ravine slightly north of Brown School and a slightly greater thickness exposed in the valley of Broad Run.

Sinks Grove Anticline.—The Sinks Grove Anticline, not previously named or described, is a prominent fold of north-central Monroe County. Starting between Back Creek and Indian Creek 1.1 miles east of Lillydale, it extends with a course slightly east of north for 10½ miles, passing just west of Collins School, 0.6 mile east of Knobs village and approximately with the alignment of Swoopes Knobs and through Bickett Knob, beyond which its axis lies one-third mile west of Sinks Grove, passes just west of Spider Den School and reaches Second Creek in the edge of Greenbrier County one-half mile west of Nickells Mill and just north of the Monroe County line. Beyond this point the arch has not been mapped.

Structure contours have not been plotted about this anticline except along its southern end but the relationships may be stated from field notes with fair approximation. From the southern end the axis rises rapidly northward, apparently to the vicinity of Bickett Knob with a rate of about 250 feet per mile, and from Bickett Knob to Nickells Mill there is hardly 50 feet of rise in 5½ miles. East of Swoopes Knobs there is a steep dip toward the Hurricane Ridge Syncline in the vicinity of Union but west of the knobs there is only a moderate dip toward the high saddle in the Knobs Syncline. Farther north in the neighborhood of Sinks Grove and Nickells Mill the fold appears to be more symmetrical about its axis.

The surface geology along the southern half of the axis is mainly that of the Bluefield Group of the Mauch Chunk but at the head of Pepper Run and in the gap south of Bickett

Knob there are Greenbrier outcrops. North of Bickett Knob the latter series forms the entire outcrop to the edge of the plateau south of Second Creek and southwest of Nickells Mill, its full thickness and almost every detail of its members being exhibited in vertical cross-section. South of Second Creek and southwest of Nickells Mill the entire Maccrady Series and the upper part of the Pocono are exposed in the valley of the creek.

Patton Syncline.—The Patton Syncline, not previously named or described, is a weak structural feature starting in the plateau lands 1½ miles south of Sinks Grove, extending northeastward for six miles and reaching Second Creek and the Monroe-Greenbrier County line 1½ miles east of Patton, beyond which it has not been mapped. Its surface geology is entirely that of the Greenbrier Series.

Maple Grove Anticline.—The Maple Grove Anticline, not previously named or described, is a poorly defined structural feature parallel to the Patton Syncline, starting in the plateau 1½ miles west of Pickaway and extending six miles northeastward to Second Creek and the Monroe-Greenbrier County line, and thence in the same direction for about one mile to the vicinity of Maple Grove School in the latter county, beyond which it has not been mapped. Its surface outcrops are confined to the lower portion of the Greenbrier Series.

Hurricane Ridge Syncline.—The Hurricane Ridge Syncline, which passes entirely across central Monroe County in a northeast-southwest direction, has already been described, pages 146-149.

Hillsdale Anticline.—The Hillsdale Anticline, not previously named or described, is a short arch which apparently lies wholly within Monroe County. Starting just south of Burnside Branch 2.7 miles southeast of Union, this fold apparently gains intensity along its northeastward course until it crosses the Hillsdale-Dorr road 0.4 mile east of the former village where it is well marked. Beyond this road it gradually flattens out and disappears just northeast of Oak Grove School, its total length being seven miles. Along the southern part of its axis the Greenbrier Series is the outcropping formation but the increase of the fold brings the Maccrady to the sur-

face 0.6 mile southeast of Hillsdale and this latter series continues at the surface for two miles after which the Greenbrier again covers it to the northern end at Oak Grove School.

Dorr Syncline.—The Dorr Syncline, not previously named or described, is a short basin east of and approximately parallel to the Hillsdale Anticline, and also wholly included within Monroe County. It may be first recognized just north of Taggard Branch and 1½ miles northeast of Willow Bend, and from this locality it extends northeastward for eight miles, crossing the Union-Gap Mills road at Schley School, passing one-half mile west of Keenan, one-fourth mile west of Dorr, beyond which it closely follows the valley of Rayburn Draft and ends three-fourths mile southwest of Second Creek village. In the vicinity of Dorr it is plainly visible but towards its end it flattens out and becomes scarcely perceptible as compared to the more evident monocline on which it is a minor wrinkle. The Greenbrier Series is the outcropping formation from the southern end to a point three-fourths mile north of Dorr, beyond which it has been eroded in the valley of Rayburn Draft, so that the Maccrady becomes the surface outcrop.

Highland Anticline.—The Highland Anticline, not previously named or described, is a short fold which originates three-fourths mile southwest of Hollywood, Monroe County, and extends northeastward into Greenbrier. Soon after its beginning it reaches and crosses Second Creek 0.9 mile north of Hollywood, then follows the valley of this creek to the sharp bend south of Highland Green School, passes just east of this school, reaches the Monroe-Greenbrier County line three-fourths mile northwest of Pleasant Valley School and 1½ miles southeast of Organ Cave. It then passes into the latter county and has not been further mapped. Through most of its length of seven miles in Monroe County it is a sharp-ridged arch, there being visible dips that vary from 10 to 50 degrees. Except at the extreme southern end where there is a brief covering of Maccrady the entire surface geology is that of the Pocono Series of the Mississippian.

Hollywood Syncline.—The Hollywood Syncline, not previously named or described, is a basin which originates in Monroe County and extends northeastward into Greenbrier.

Starting at the northern base of Little Mountain, about 1½ miles northeast of Gates, it passes one-fourth mile west of Hollywood, crosses Second Creek one-half mile farther on, crosses Laurel Creek one-half mile east of and above its mouth, continues with an alignment that is slightly east of and approximately parallel to Carpenter Creek, passing 0.4 mile east of Pleasant Valley School, and crosses the Monroe-Greenbrier County line at the southern extremity of White Rock Mountain, its total length in Monroe being 10 miles. In Greenbrier its further course has not been mapped. For the first 1½ miles of its length its axis is covered by the Greenbrier Series, after which there is a belt of Maccrady three-fourths mile wide, followed by the Pocono in the vicinity of Hollywood. This latter series continues as the surface outcrop almost to White Rock Mountain where the upper part of the Chemung Series of the Devonian apparently outcrops. There is much variation of dips at different points so that an average could hardly be stated, but the axis in general appears to rise rather rapidly northeastward toward White Rock Mountain.

Harts Run Anticline.—The Harts Run Anticline, not previously named or described, is a fold of considerable proportions which starts one mile north of Little Mountain and 1½ miles west of Red Mill, Monroe County, and extends northeastward, crossing Second Creek 0.7 mile southeast of Hollywood, passing through the western end of Daniels Ridge, crossing Laurel Creek 1.3 miles southeast of and above its mouth, crossing the Monroe-Greenbrier County line 1.8 miles northeast of Pleasant Valley School, and crossing Harts Run diagonally at the mouth of Rock Lick Run, beyond which its course has not been mapped. Its total length as described is 11 miles, the portion in Monroe County being nine miles. It is a gentle flexure at its southern end but farther north, especially in the edge of Greenbrier County, it becomes a sharp uplift with observed dips of 50 degrees or more. The surface geology at the extreme southern end is that of the Greenbrier Series, but the northeastward rise of the axis soon carries this formation above the topography and there is a belt of Maccrady one-half mile wide. About 1½ miles south of Holly-

wood the Pocono Series comes above drainage and continues as the surface outcrop for 3½ miles to the northern side of Daniels Ridge where the Chemung Series of the Devonian comes up and covers the arch to the Greenbrier County line. At the crossing of Harts Run the surface strata appear to be in the contact zone of the Chemung and Portage.

Kates Mountain Syncline.—The Kates Mountain Syncline, not previously named or described, is a rainbow-shaped basin which originates in the vicinity of the point where Devil Creek empties into Second Creek, 1½ miles northeast of Red Mill, Monroe County, then extends approximately northward for three miles, crossing Daniels Ridge 0.7 mile northwest of Parker School and Laurel Creek 1.6 miles east of and above its mouth. Here it turns northeastward but apparently remains on the northwestern side of Laurel Creek and reaches the Monroe-Greenbrier County line 0.7 mile northeast of Rich Mountain and 1.3 miles northwest of Glace and thereafter for the next two miles approximately follows the crest of Kates Mountain which is there the line between the two counties. It then passes wholly into Greenbrier County where it has not been further mapped, its length as described being nine miles. At its southern end the Maccrady Series outcrops in the valley of Second Creek but this is soon succeeded by the Pocono Series which covers the axis for two miles to the northern side of Daniels Ridge, after which the Chemung Series of the Devonian comes to the surface and so remains until the basin passes into Greenbrier County.

Glace Anticline.—The Glace Anticline, not previously named or described, is a sharp but narrow fold which apparently starts at the northern base of Cove Mountain one-half mile northeast of Elk Knob, Monroe County, and extends northeastward, its axis being slightly east of Little Laurel Creek and just east of Hinton School and then passing up the upper valley of Laurel Creek, and lying just west of Glace and crossing the Monroe-Greenbrier County line one-half mile northward from Glace. Its length as described is five miles, its further extent in Greenbrier County not having been mapped.

Pedro Syncline.—The Pedro Syncline, not previously named or described, is a deep, intermontane basin which originates near the point where Little Devil Creek empties into Devil Creek 1.8 miles northeast of Red Mill, Monroe County, and extends northeastward, its course being much more toward the east than is that of the Glace Anticline. After following up Little Devil Creek to its head the basin passes into the valley of Cove Creek, its position being about one-half mile south of the creek from which it is in part separated by a low ridge, and its axis passing one-third mile south of Pedro. Farther on at the head of Cove Creek just northwest of Big Branch the syncline crosses the creek and then continues one-half mile farther and crosses from Monroe County, West Virginia, into Alleghany County, Virginia. Its course in the latter county has not been mapped, its length in Monroe being eight miles. At its southwestern end the basin is covered by a brief outcrop of the Maccrady Series but this is soon followed by Pocono which appears to form the surface for about 1½ miles along Devil Creek, after which the Maccrady recurs and remains the outcropping formation for three miles to the head of Devil Creek. Beyond this point the structure descends still deeper and there is an oblong outcrop of Greenbrier Series for 2½ miles in the region south of Cove Creek and southwest of Pedro. From the latter point northeastward for three-fourths mile the Maccrady is again brought to the surface as the axis rises toward the northeast, this outcrop being followed by another sector of Pocono which continues to the Alleghany County line.

Nigger Mountain Anticline.—The Nigger Mountain Anticline, not previously named or described, is a sharp but narrow fold which starts on the southern slope of Middle Mountain 1½ miles northeast of Roxalia, Monroe County, passes between Middle Mountain and Wolf Hills for one mile with a course that is slightly north of east, then turns rapidly to North 25 degrees East and so continues, passing through the western end of Nigger Mountain, crossing Cove Creek 1½ miles due east of Pedro and crossing the Monroe-Alleghany County line within the next one-half mile, its total length in

Monroe County being 4½ miles. Its further course in Alleghany County, Virginia, has not been mapped. Along its length as mapped the outcropping rocks appear to be wholly those of the Chemung Series of the Devonian.

Wolf Hills Syncline.—The Wolf Hills Syncline, not previously named or described, is a structural feature lying southeast of and almost exactly parallel to the Nigger Mountain Anticline, its origin being about midway between Middle Mountain and Back Creek and less than two miles northeast of Roxalia. From this locality it passes eastward through Wolf Hills and then turns northeastward and, remaining northwest of Back Creek, extends through Nigger Mountain, crosses Cove Creek at the sharp bend one mile northwest of Cove Creek School, and finally crosses the Monroe-Alleghany County line 0.6 mile beyond Cove Creek. In the latter county it has not been mapped, its total length as indicated in Monroe County being 4½ miles. The Chemung Series of the Devonian appears to form the entire surface outcrop along its axis in Monroe County.

North Fork Syncline.—The North Fork Syncline, not previously named or described, is a sharp and narrow basin located in the highly disturbed Potts Valley region of southern Monroe County. This structural depression is an offshoot from the more prominent Waiteville Syncline, its point of divergence being on Potts Creek near the junction of North and South Forks two miles east of Waiteville. From this locality it extends approximately westward up the valley of North Fork five miles and crosses the line between Monroe County and Giles County, Virginia, beyond which it has not been mapped. At its beginning the surface formation is apparently the Hamilton Series of the Devonian but the axis of the basin rises rapidly westward, bringing the Marcellus to the surface one mile north of Waiteville. This belt of black shale covers the basin for about one mile and is followed by a strip of Oriskany 2½ miles long and finally by the Clinton Series of the Silurian in the last one-third mile east of the Virginia line. This rapid westward rise along the structure would indicate that the basin might not extend far into Giles County.

Fork Mountain Anticline.—The Fork Mountain Anticline, not previously named or described, is a sharp structural hogback that originates in the angle between the North Fork and Waiteville Synclines, becoming plainly visible as such about one mile northwest of Waiteville. From this locality it follows the ridge of Fork Mountain in a course slightly south of west and enters Giles County 4½ miles west of Waiteville or about 1½ miles northeast of Kire Station, its visible length in Monroe County being 3½ miles. In Giles County its further extent has not been mapped. This anticline is quite symmetrical about its axis, there being steep dips on either side, but the structure rises rapidly westward, the surface outcrop north of Waiteville being Marcellus, followed by a short belt of Oriskany, the horizon of which is soon carried into the air leaving the Clinton Series of the Silurian as the main outcrop on the mountain.

Waiteville Syncline.—The Waiteville Syncline, not previously named or described, is the principal basin of the Potts Valley region of Monroe County. Entering from Giles County, Virginia, just east of Kire Station and five miles westward from Waiteville, it extends down South Fork of Potts Creek to Waiteville with a course that is north of east, then turns more toward the north with the valley of main Potts Creek for three miles, but again approximately resumes its earlier trend for the next four miles, its axis being slightly south of the creek and 0.4 mile south of Laurel Branch, and passes out of Monroe into Craig County, Virginia, 1.2 miles east of Laurel Branch. In Craig County its position was noted as continuing northeastward approximately with the creek valley for five miles through Linton and Paint Bank, beyond which it has not been mapped.

The total length of this basin in Monroe County is 12 miles and it has been followed four miles into Virginia, making a recorded length of 16 miles, but it is quite apparent that the structure is much longer and this observed distance may be only a brief sector of a long basin in Virginia, since it is a deep fold at Kire and probably follows southwestward toward New River through the long valley of Stony Creek, while it is of even larger proportions at Paint Bank and there

is much reason to believe it follows for many miles northeastward through the valley of Potts Creek.

Throughout its length in Monroe County its axis is covered with sediments of Devonian age, the outcrop at the Giles County line and northeastward for four miles being the Marcellus Series, after which there is a belt of Hamilton in the vicinity of Waiteville, followed by the Genesee which begins 2½ miles northeast of Waiteville and continues to the Craig County line.

Back Valley Anticline.—The Back Valley Anticline, not previously named or described, is a sharp uplift which crosses southern Monroe County, entering from Giles County, Virginia, with the ridge of Little Mountain, one mile southeast of Kire Station and 4½ miles southwest of Waiteville. From the Virginia line it extends northeastward through the short length of Little Mountain, crosses Crosier Branch slightly south of the Norfolk & Western Railway, crosses Ray Branch just north of Ray Station and one-half mile south of Waiteville, passes a little north of Arnold Knob, keeps slightly south of the head of Trout Branch and passes through the Back Valley, crossing the Monroe-Craig County line one-half mile east of Sugar Grove School. In Craig County it follows northeastward with Back Valley to Paint Bank Branch, beyond which has not been mapped. Its length as described in Monroe County is 13 miles and that in Craig County 3 miles, but it is apparent that it has a much further extent both in Giles and Craig Counties.

Throughout its observed length this is a sharply folded anticline, the strata north of Back Valley being in part faulted and overturned. At the Giles County line the axis is covered by the Clinton Series but it descends northeastward and there are outcrops of Oriskany both east and west of Crosier Branch. About one mile east of Ray the axis rises, bringing the Clinton again to the surface, followed by the White Medina and Red Medina, and on the headwaters of Trout Branch by the Martinsburg Series of the Ordovician, while the Moccasin and Stones River (Chickamauga) Limestones outcrop in the Back Valley next to the Craig County line and the top

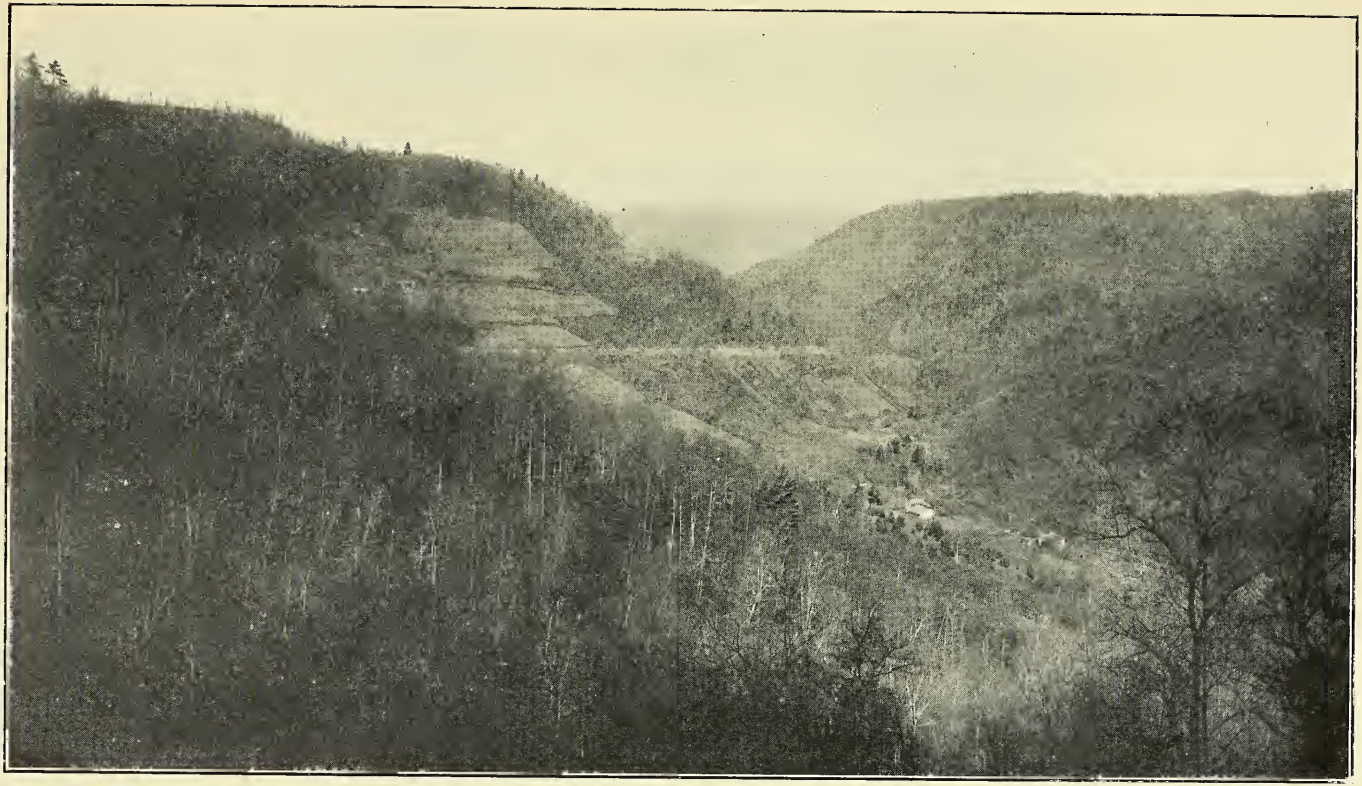


PLATE VIII.—Looking north down Pipestem Creek from spur of Tallery Mountain 2 miles south of True, Summers County. Cliff on high ridge at left is Princeton Conglomerate. River Ridge (right middle) is all Hinton Group. Faint peak in extreme rear is Stonelick Knob of Keeney Mountain, capped by Pottsville. (Photo. by Palmer & Fowler).

of the Beekmantown is above drainage on Paint Bank Branch in the latter county.

Ray Syncline.—The Ray Syncline, not previously named or described, is a narrow fold of southern Monroe County, entering from Giles County, Virginia, about two miles southeast of Kire Station and 4½ miles southwest of Waiteville. Passing northeastward it crosses Crosier Branch 0.4 mile south of the Norfolk & Western Railway, passes just south of Ray and enters Craig County three miles northeast of that point, its total length as recorded across Monroe County being 7½ miles, and its further length in Giles and Craig Counties, Virginia, not having been mapped. Along the axis next to Giles County, there is about one mile of Marellus followed by Oriskany as far as Crosier Branch, after which the Marcellus again covers it for three miles, with a mile or more of Oriskany next to the Craig County line.

Crosier Anticline.—The Crosier Anticline, not previously named or described, is the most southern fold in Monroe County, entering from Giles County, Virginia, about one-third mile north of the common corner of Monroe, Giles, and Craig, and extending northeastward in a line slightly north of the ridge of Potts Mountain for 7½ miles and passing into Craig County three miles eastward from Ray. Its principal surface outcrop appears to be that of the Clinton Series of the Silurian.

Anticlines and Synclines, Summers County.

Boggs Knob Anticline.—The Boggs Knob Anticline of Hennen[11] is a shallow fold, caused by a slight reversal of the prevailing northwest dip of the rocks in northwestern Summers, southeastern Fayette, and western Greenbrier Counties. From Boggs Knob in Greenbrier County, northeast of which it has not been studied, this anticline extends southwestward about one mile, crosses the Greenbrier-Fayette County line one-half mile southward from Mountain School, continues with the same course across the southeastern corner of Fayette for 5½ miles crossing Sewell Creek 0.8 mile north of

[11]Ray V. Hennen, Fayette Report, W. Va. Geol. Survey, pp. 94-95; 1919.

Springdale and passing 0.4 mile southeast of Meadowbridge, and enters Summers County one-half mile southeastward from Meadowbridge. In the latter county it immediately turns southward and so continues for four miles, crossing Coon Creek 0.7 mile northeast of Tina, passing 0.3 mile west of Lockbridge, and crossing Lick Creek two miles southwest of Green Sulphur Springs. Here it turns southwestward again for 5½ miles, crossing the end of Big Swell Mountain at Jones School, crossing Laurel Creek just above and east of Paynes School and one mile southeast of Sandstone, passing through the northwestern end of Chestnut Mountain, and crossing New River and entering Raleigh County 1.1 miles below and northwest of Brooks. In Raleigh its length is only three miles, its direction being the same as in the adjoining part of Summers; and it passes out of this southern extremity of Raleigh one mile northwest of Swell Mountain and again enters Summers, its further length being apparently about 1½ miles and its direction the same as in Raleigh. It loses its identity between Righthand Fork and Madam Creek three miles northwest of Hinton. Its total length as described is 20½ miles of which 11 miles are in Summers County.

Along the length of this anticline there is only a slight relief above the general slope of the monocline. At the Fayette County line the elevation of the Avis Limestone is a little more than 2,000 feet and in the region just west of Lockbridge it is 2,050 feet, making a low dome, but farther south it soon falls to the former level and so remains to the end of the arch. The surface geology along the axis is entirely that of the Mauch Chunk Series, the outcrop at the Fayette line being the Bluestone Group, followed by a belt of Princeton on Coon Creek. The Bluestone is again present in two western prongs of Gwinn Mountain, the Princeton and Hinton Groups being exposed on the head of Claypool Branch and on the south slope of Gwinn Mountain. For the remaining length of the fold southward the Hinton Group is the principal surface formation, there being an outcrop of Princeton on Chestnut Mountain and the upper part of the Bluefield Group being above drainage on New River. Along the Raleigh-Summers County line east of Freezeland Moun-

tain a slight amount of the Pocahontas Group of the Pottsville Series of the Pennsylvanian is preserved and below this remnant there are outcrops of Bluestone and Princeton followed by Hinton on the lower slopes.

Springdale Syncline.—The Springdale Syncline of Hennen[12] is a shallow basin lying 1½ to two miles east of and approximately parallel to the Boggs Knob Anticline. This syncline enters Fayette County from Greenbrier slightly less than one mile northwest of Turniphole Mountain, extends southwestward across Fayette County and a western projection of Greenbrier for 2½ miles and passes into Summers County one-third mile southeast of its most northern angle, or three miles eastward from Meadowbridge. In Summers it continues its southwestward course 2½ miles to the northern base of Gwinn Mountain, passing through Wallowhole Mountain and crossing the head of Coon Creek Valley 0.2 mile west of Lane School. It then turns southward for 2½ miles, passing through Gwinn Mountain 0.7 mile east of Lockbridge and crossing Lick Creek 0.8 mile southwest of Green Sulphur Springs. Here it again turns southwestward for the remaining 11 miles of its length, the distance from Lick Creek to New River along the axis in Summers County being seven miles. Beyond Lick Creek it passes through Big Swell Mountain one-third mile west of Mountain View School, crosses Laurel Creek just above and east of Mudlick Branch and two miles southeast of Sandstone, crosses Chestnut Mountain at a low gap in the vicinity of Ward School, and crosses New River and the Summers-Raleigh County line 0.6 mile south of Brooks. In the southern end of Richmond District, Raleigh County, it has a length of only 1½ miles and it again enters Summers one-half mile southeast of Swell Mountain, and extends through Jumping Branch District of the latter for 2½ miles, crossing Madam Creek at the mouth of Righthand Fork 1.7 miles west of Hinton Station and apparently ending in the slope one-half mile south of this creek. Its total length as described is 18½ miles, of which 14½ miles are in Summers County, its northeastward extent in Greenbrier County not

[12]Ibid., p. 95.

having been mapped. Throughout its known length there is little variation in the structural height, the elevation of the Avis Limestone at the Greenbrier-Summers County line along Wallowhole Mountain being slightly less than 2,000 feet and remaining much the same southward to New River, there being a lower area in the region west of Barksdale and northwest of Hinton where it descends to less than 1,950 feet.

Along the axis of this basin in Wallowhole Mountain, Gwinn Mountain, and Big Swell Mountain there are remnants of the Pocahontas Group of the Pottsville Series of the Pennsylvanian, but otherwise the surface outcrops belong to the Mauch Chunk Series of the Mississippian, the upper three groups, Bluestone, Princeton, and Hinton, being represented in the slopes of the deeply eroded plateau, and only the Bluefield Group being entirely below drainage.

Dunn Anticline.—The Dunn Anticline, which extends partly across central and southwestern Summers County and into Mercer, has already been described, page 141.

Bellepoint Syncline.—The Bellepoint Syncline, lying parallel to and southeast of the Dunn Anticline in Summers and Mercer Counties, has already been described, page 141-142.

Alderson Anticline.—The Alderson Anticline, having its known length partly in eastern Summers and partly in northwestern Monroe County, has already been described, page 149.

Creamery Syncline.—The Creamery Syncline, which originates in eastern Summers and soon afterward passes into Monroe County, has already been described, pages 149-150.

Abbs Valley Anticline.—The Abbs Valley Anticline, which extends across the extreme southern end of Summers County, has already been described, pages 142-146.

STRUCTURE CONTOURS ON AVIS LIMESTONE.

In all of Summers County, and in about three-fourths of Mercer or the part north of Stony Ridge, and in the approximate northwestern third of Monroe, where structural disturbance has been slight and the rocks are still almost horizontal, the base of the **Avis Limestone** has been used as the

basis of the structural contours as exhibited in green color on Maps II, IV, and VI. This limestone is from 20 to 40 feet thick, as will later be described, and occurs slightly above the middle of the Hinton Group of the Mauch Chunk Series of the Mississippian. Its outcrop is extensive in the middle third of Summers County, there being a strip along the western edge where it lies under drainage and along the southeastern edge where its horizon belongs above the topography. In Mercer County it has two or three geographic zones of outcrop through the central part but goes under drainage in the western coal fields and overshoots the topography toward the south. In Monroe County it is everywhere above the topography, even along the western edge, but the comparatively small portion of this county that adapts itself to the use of contours makes it scarcely advisable to shift to a lower key rock. In the western parts of Summers and Mercer a structure map has previously been prepared by Krebs[13] on the No. 3 Pocahontas Coal, and these contours have been redrawn in the present Report by reducing them to the level of the Avis Limestone, without making independent observations except to determine the essential intervals from the No. 3 Pocahontas down to the Avis at various points.

In the eastern portions of Rock and Jumping Branch Districts, Mercer County, and the eastern part of Jumping Branch District, Summers County, no contours were drawn by Mr. Krebs and these regions lie outside of the territory strictly embraced in the present Report but several trips were made by the writer through this belt to determine the essential features of the structure and to fill in this important gap. Naturally, this work was not done with so much detail as in other districts farther east but it is believed that the results are reasonably satisfactory.

In the remainder of the area contoured on the Avis Limestone many hundreds of observations were taken on the key rock itself and on other known stratigraphic horizons. Elevations were mainly obtained by the use of the aneroid, checked on the nearest government spirit-level determinations

[13]C. E. Krebs, Raleigh County and Western Portions of Mercer and Summers Counties, W. Va. Geol. Survey; 1916.

as recorded on the topographic maps, and in some cases it was possible to make hand-level measurements directly from bench marks or posted elevations.

It has been repeatedly demonstrated that elevations obtained by the aneroid under the conditions above named are seldom more than 25 feet too high or too low and usually not more than 5 or 10 feet from the truth and if there were no other source of error these figures might be taken as the probable limit of inaccuracy. By far the greatest uncertainty, however, will be found in those localities where the Avis Limestone horizon is either below drainage or above the topography and where its position must be fixed by using an interval from some other formation. There is not only a generally increasing thickness of the Mauch Chunk Series from north to south which would not be troublesome if it occurred at a constant rate, but there are also local variations of interval due to disconformities that may not always be determined, so that an element of error is introduced which is far in excess of that usually prevailing in the coal fields of counties farther north and west. As far as possible these uncertainties were reduced by making numerous detailed vertical cross-sections of the strata at favorable points and numerous special measurements of intervals from place to place.

In western Monroe County, where the Avis Limestone horizon is entirely above the topography, its relationships to the upper beds of the Greenbrier Series were obtained by measuring the entire Mauch Chunk Series from the Greenbrier River just west of Alderson to the top of Keeney Knob in the edge of Summers County, and farther south by using the heavy sandstones of the lower portion of the Mauch Chunk, the intervals of which from the Avis had been determined slightly to the westward.

The principal structural results of these many observations are condensed in the following tables, showing intervals above and below the base of the Avis Limestone at various localities in the three counties, the figures having been used in determining contours on this plane where direct measurements were impossible. Their use in conjunction with the measured sections published in Chapter V is recommended

for those who make further studies of these rocks. Several columns in the tables show vacant spaces either because the members named at the left belong above the tops of the ridges or because they lie below drainage and there are no present data to show the information called for. Figures in parentheses indicate that the member was not found in the locality called for at the top of the column, or its horizon was above the topography or below drainage, sufficient general information being available to approximate its interval fairly well by deduction. In order to find the approximate elevation of any stratum its interval from the base of the Avis Limestone should first be obtained by using the tables or by referring to the local section measured for the nearest point. Having the structure contorus as a guide the stratum should then be easily found:

Intervals above (Base of) Avis Limestone to (Bases of) Other Members—Mercer, Monroe, and Summers Counties.

MEMBER	MERCER COUNTY						MONROE COUNTY						SUMMERS COUNTY					
	Athens	Elgood	Nemours	Pride	Princeton	Stony Gap	Alderson	Knobs	Nickells Mill	Peterstown	Raines Corner	Red Sulphur Springs	Green Sulphur Springs	Hinton	New Richmond	Pence Springs	Tallery Mountain	Warford
Pineville Sandstone	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1320	.....	.....	.....
No. 6 Pocahontas Coal	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1175	.....	.....	.....
No. 3 Pocahontas Coal	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1045	.....	.....	.....
Keystone Coal	.....	.....	.....	.....	.....	.....	(1015)	.....	.....	.....	.....	.....	(835)	(975)	885	.....	.....	.....
Pottsville Series (base)	(1250)	.....	1375)	(1100)	(1375)	(1375)	1015	.....	.....	.....	.....	.....	835	955	830	.....	.....	.....
Bent Sandstone	(1050)	.....	(1100)	925	1075	1075	750	.....	.....	.....	.....	.....	770	(925)	800	.....	.....	.....
Hunt Coal	(990)	.....	1050	(865)	1010	1010	(700)	.....	.....	.....	.....	.....	(740)	(875)	(750)	.....	.....	.....
Bratton Sandstone	(920)	.....	(975)	(815)	950	950	(650)	.....	.....	.....	.....	.....	(700)	(830)	(700)	.....	.....	.....
Upper Belcher Sandstone	(875)	.....	(925)	775	900	900	(575)	.....	.....	.....	.....	.....	665	790	635	.....	.....	.....
Lower Belcher Sandstone	(800)	.....	(850)	(725)	850	850	(500)	.....	.....	.....	.....	.....	560	(700)	535	.....	.....	.....
Upper Mud Sandstone	(770)	.....	(820)	(680)	810	810	(480)	.....	.....	.....	.....	.....	(525)	(660)	(490)	.....	.....	.....
Lower Mud Sandstone	(740)	.....	(790)	(665)	(780)	(780)	(455)	.....	.....	.....	.....	.....	(495)	(620)	(450)	.....	.....	.....
Glady Fork Sandstone	(700)	.....	(750)	(650)	750	750	430	.....	.....	.....	.....	.....	470	(515)	430	.....	.....	.....
Pipestem Coal	(650)	.....	(700)	(600)	(700)	(700)	(400)	.....	.....	.....	.....	.....	435	(485)	(400)	.....	.....	.....
Princeton Sandstone	(450)	450	500	(400)	500	500	(340)	.....	.....	.....	.....	.....	380	415	365	325	415	410
Pluto Coal	(385)	(385)	460	(360)	410	410	(265)	.....	.....	.....	.....	.....	(320)	330	(320)	(260)	(350)	(335)
Falls Mills Sandstone	(275)	(275)	275	(250)	275	275	165	.....	.....	.....	.....	.....	220	250	(200)	115	230	225
Fivemile Coal	(240)	(240)	(240)	(230)	(240)	(240)	(140)	.....	.....	.....	.....	.....	(185)	(230)	(190)	(90)	(190)	(185)
Tallery Sandstone	200	200	200	200	200	200	100	.....	.....	.....	.....	.....	145	200	(140)	(75)	175	150
Tallery Coal	(185)	(185)	(185)	(185)	(185)	(185)	(100)	.....	.....	.....	.....	.....	(145)	(200)	(140)	(75)	170	(145)
Low Gap Sandstone	150	150	160	(150)	160	160	(80)	.....	.....	.....	.....	.....	115	(140)	(110)	(50)	(125)	100
Avis Sandstone	100	100	100	100	100	100	(50)	.....	.....	.....	.....	.....	60	80	(60)	(30)	75	60
AVIS LIMESTONE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Intervals below (Base of) Avis Limestone to (Bases of) Other Members—Mercer, Monroe, and Summers Counties.

MEMBER	MERCER COUNTY						MONROE COUNTY						SUMMERS COUNTY					
	Athens	Elgood	Nemours	Pride	Princeton	Stony Gap	Alderson	Knobs	Nickells Mill	Peterstown	Raines Corner	Red Sulphur Springs	Green Sulphur Springs	Hinton	New Richmond	Pence Springs	Tallery Mountain	Warford
AVIS LIMESTONE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Payne Branch Sandstone	60	60	(60)	60	(60)	(90)	50	.....	.....	(60)	(50)	(50)	(40)	(40)	(40)	(50)	50	65
Hackett Sandstone	130	130	(125)	130	(100)	(190)	(80)	.....	.....	(100)	(110)	(110)	105	160	150	140	135	110
Tophet Sandstone	(375)	375	(375)	(375)	(375)	(375)	(165)	.....	.....	(300)	(275)	(275)	245	375	275	(275)	250	(260)
Tophet Coal	375	(375)	(375)	(375)	(375)	(375)	(165)	.....	.....	(300)	(275)	(275)	(245)	(375)	(275)	(275)	250	(260)
Goodwyn Sandstone	(425)	(425)	(450)	(425)	(425)	425	215	.....	.....	(375)	(325)	(325)	305	400	335	(310)	345	315
Upper Bellepoint Sandstone	(600)	600	(550)	(600)	(600)	(575)	335	.....	.....	(475)	(425)	(425)	355	460	400	375	(465)	415
Middle Bellepoint Sandstone	(700)	(700)	(625)	(700)	(700)	(675)	390	.....	.....	(550)	(500)	(500)	420	510	480	(450)	520	465
Lower Bellepoint Sandstone	(775)	(775)	(700)	(775)	(775)	(775)	440	.....	.....	(600)	(550)	(550)	(470)	560	510	(500)	(570)	(500)
Stony Gap Sandstone	(875)	875	825	(875)	(875)	900	510	.....	.....	(700)	660	660	(600)	660	625	575	675	575
Clayton Sandstone	(950)	950	925	(950)	(975)	1000	600	.....	.....	(780)	735	735	(675)	(710)	(700)	640	(725)	(660)
Graham Sandstone	.....	.....	1000	.....	.....	1125	(675)	.....	.....	(880)	810	810	(750)	(785)	(775)	730	(800)	(725)
Graham Coal	.....	.....	1075	.....	.....	1250	(690)	.....	.....	(950)	(850)	(850)	(775)	(835)	(800)	(780)	(850)	(790)
Bertha Sandstone	.....	.....	1150	.....	.....	1275	715	.....	.....	(1000)	900	925	(825)	(875)	(850)	840	(890)	870
Bradshaw Sandstone	.....	.....	(1450)	.....	.....	1500	935	.....	.....	(1225)	1100	1075	(925)	(1025)	(950)	1000	(1035)	1000
Indian Mills Sandstone	.....	.....	(1550)	.....	.....	1625	1050	.....	.....	(1325)	1225	1200	(975)	1080	(1000)	1075	(1100)	1200
Raines Corner Limestone	.....	.....	1650	.....	.....	(1750)	1370	.....	.....	(1425)	1275	1250	(1025)	1225	(1050)	1125	(1150)	(1250)
Raines Corner Coal	.....	.....	(1700)	.....	.....	1800	(1385)	.....	.....	(1475)	1285	.....	1050	(1250)	(1075)	1150	(1175)	(1275)
Droop Sandstone	.....	.....	(1750)	.....	.....	1875	1445	1550	1550	(1550)	(1385)	.....	1100	1300	(1125)	1200	(1250)	1350
Ada Shale	.....	.....	1850	.....	.....	1950	1520	1625	1625	(1625)	(1485)	.. ..	1200	(1375)	(1225)	1300	(1400)	(1500)
Webster Springs Sandstone	.....	.....	1900	.....	.....	(1975)	1550	1665	1665	(1675)	(1535)	....	(1225)	(1400)	(1250)	1325	(1450)	1550
Glenray Limestone	.....	.....	2000	.....	.....	(2050)	1610	1790	1790	(1800)	(1660)	.....	1310	1480	(1335)	1400	(1600)	1700
Lillydale Shale	.....	.....	2125	.....	.....	2150	1725	1920	1920	(1925)	(1785)	.....	1385	1580	(1400)	1500	(1800)	1900
Alderson Limestone	.....	.....	2425	.....	.....	2475	1850	2050	2050	(2250)	(1925)	.....	.....	.....	.....	.....	1650	2100
Union Limestone	.....	.....	2675	.....	.....	2750	(2000)	2205	2205	(2550)	(2075)	.....	.....	.....	.....	.....	.....	2300
Pickaway Limestone	.....	.....	3075	.....	.....	3175	(2250)	2440	2440	(2850)	(2325)	.....	.....	.....	.....	.....	.....	2675
Taggard Limestone	.....	.....	3100	.....	.....	3180	(2275)	2465	2465	(2875)	(2350)	.....	.....	.....	.....	.....	.....	(2700)
Greenbrier Series (base)	.....	.....	3750	.....	.....	3950	(2800)	2960	2960	(3475)	(2850)	.....	2080	2635	(2100)	(2700)	(3000)	3325

CROSS-SECTIONS.

In southern Mercer County, including Stony Ridge and all points south of it, and in the southeastern two-thirds of Monroe County, the rocks have been too much distorted to be used as the basis of a structure map, being frequently overturned, faulted, or otherwise so disturbed that they could not be successfully contoured. In this region, with the help of Mr. Price as draftsman, six cross-sections have been compiled to show in graphic manner the position of the beds. The three prepared for Mercer County do not extend much northwest of Bluestone River, since their further projection in that direction would add little to the knowledge of the comparatively flat structure that may be gained from the structure contours. In Monroe County, however, they have been drawn entirely across the area. All these cross-sections have been made on a vertical and horizontal scale of 1-62,500, or 5,208 feet to the inch, which is the linear scale of the topographic maps, and all of them extend approximately at right angles to the line of strike, some slight deviations being made from this rule to include certain interesting features.

Cross-Section AA′.—Cross-Section AA′, approximately 8.7 miles long, starts at a low point just west of Bluestone River and one-half mile north of Bramwell, Mercer County, and extends southeastward across Bluestone River, Redoak Ridge, Stony Ridge, Bluefield, and South Bluefield, to the line of Mercer County with Bland County, Virginia, in the crest of East River Mountain south of Bluefield, as shown on Map II.

Cross-Section BB′.—Cross-Section BB′, approximately 9.7 miles long, starts at a bend in Bluestone River 1½ miles northeast of Kegley, Mercer County, and extends southeastward, crossing the end of Blackoak Mountain, passing through Princeton, crossing Stony Ridge, Spangler Valley, and East River, and reaching the crest of East River Mountain and the Bland County line two miles south of Ingleside, as shown on Map II.

Cross-Section CC′.—Cross-Section CC′, approximately 14½ miles long, begins on Bluestone River at the mouth of

Double Cabin Branch 2.3 miles northeast of Eads Mill, Mercer County, extends southeastward, passing through Pride and about 1½ miles east of Athens, and through the western end of Christian Ridge, crossing East River at Kellysville and reaching the line between Mercer County and Giles County, Virginia, and the crest of East River Mountain 2½ miles southeast of Kellysville, as exhibited on Map II.

Cross-Section DD′.—Cross-Section DD′, about 7½ miles long, starts at the Summers-Monroe County line 0.6 mile eastward from Neponset, extends southeastward across the latter county, passing just southwest of Cloverdale, crossing Chimney Ridge 1½ miles eastward from Peterstown, and reaching the top of Peters Mountain and the Monroe-Giles County line three miles southeast of Peterstown, as shown on Map IV.

Cross-Section EE′.—Cross-Section EE′, approximately 22 miles long, starts at the Summers-Monroe County line just west of the mouth of Wolf Creek and 2½ miles southwest of Alderson, extends southeastward across Monroe County, crossing Swoopes Knobs two miles west of Union, passing through Salt Sulphur Springs, crossing Little Mountain one mile northeast of Zenith and Peters Mountain two miles southeast of Zenith, crossing Fork Mountain in Potts Valley 3.2 miles westward from Waiteville, and reaching the line of Monroe with Craig County, Virginia, and the crest of Potts Mountain 3.2 miles southwest of Waiteville, as exhibited on Map IV.

Cross-Section FF′.—Cross-Section FF′, about 16½ miles long, begins at the Greenbrier-Summers County line on Second Creek one-half mile east of Patton, extends southeastward, passing through Second Creek village, the northern end of Eads Ridge, the western part of Daniels Ridge and the gap made through Middle Mountain by Little Devil Creek, crossing Gap Mountain 2½ miles northeast of Gap Mills, Peters Mountain 3.1 miles southeast of Gap Mills, crossing Potts Creek one mile east of Laurel Branch, crossing Little Mountain (of Potts Valley), Back Valley, and reaching the Monroe-Craig County line and the crest of Potts Mountain three miles southeast of Laurel Branch and 1.8 miles southwest of Nicholson Knob, as shown on Map IV.

UNCONFORMITIES.

Unconformities of the generally accepted classic type, where the term is limited to a tilted or irregularly eroded surface that has been recovered by horizontal strata so that an angular junction of the beds of different age is formed, are not common in the rock column of Mercer, Monroe, and Summers Counties, although there are a few important examples. There are numerous instances of disconformities, however, where certain formations are locally or even regionally absent, the remaining beds being in parallel position and indicating that the absent beds probably never were deposited.

In the descending rock column of the three counties an important break in the succession is found at the contact of the Pottsville Series of the Pennsylvanian with the underlying Mauch Chunk Series of the Mississippian. Here the coarse and often conglomeratic sandstones of the upper Coal Measures rest upon red shales and green, flaggy, micaceous sandstones, almost totally devoid of coal and lacking most of the typical Upper Carboniferous flora, indicating an entirely different mode of accumulation and probably some stages of exposure to air and consequent erosion. Except in the immediate contact zone, however, where irregularities of surface have been caused by differential erosion of the top of the Mauch Chunk, and where the low areas were later filled by thicker lenses of the Pottsville, there is no generally perceptible disagreement in the dip of the beds, indicating that little folding took place in the lapse of time that occurred between Mauch Chunk and Pottsville deposition. There is, of course, a northward convergence of the beds caused by the general thinning of the strata of both series in that direction, but this is merely the normal development of muds and sands which are carried out to sea by a gradually decreasing current. A further and perhaps more important difference between the two series in the area under study is revealed by the presence of numerous zones of marine fossils in the Maunch Chunk, recurring almost to its very top, and by their virtual absence from both the Pocahontas and New River Groups of the

Pottsville, there being only a few recorded fresh- or brackish-water fossils in the former with the addition of a very scanty marine fauna in the latter. Throughout the Appalachian region the same conditions noted above are general, except that toward the northeast the marine faunas of the Mauch Chunk almost wholly disappear.

Within the limits of the Mauch Chunk Series minor disconformities are found where the Princeton Conglomerate rests upon the red shales of the Hinton Group and also farther down where the quartzitic (but not conglomeratic) Stony Gap Sandstone (Hinton of Stevenson) lies on the red beds of the upper portion of the Bluefield Group. At the extreme base of the Mauch Chunk in these southern counties, however, there is only a gradual transition from the older and more massive limestones of the Greenbrier Series into those of the more shaly and younger Bluefield Group of the Mauch Chunk, the most abrupt change of any character being the appearance of beds of shale in the Mauch Chunk as compared to their almost total absence in the Greenbrier. In counties and States farther north this gentle transition does not generally prevail, there being usually a distinct change from massive limestones to red shales.

At the base of the Greenbrier Series its massive limestones rest upon the red or purple shales of the Maccrady Series which are largely devoid of fossils. These latter beds in the area under study vary in thickness from 50 to 350 feet and represent only the middle portion of the same formation as it occurs at its type locality in Smyth County, Virginia, where it is 700 to 800 feet thick with some highly fossiliferous marine limestones in its upper portion and with beds of black shale containing thin coals in its lower part. Disconformities of considerable importance at both the top and bottom of the Maccrady Series in Mercer, Monroe, and Summers Counties are therefore quite apparent.

At the base of the Pocono Series, which is also the base of the Mississippian in the entire region from southwest Virginia northeastward through the Appalachian States, there is a disconformity of first magnitude in the southern counties of West Virginia, the great Catskill Series of red and

green shales and reddish or green sandstones which characterizes the Upper Devonian of northern West Virginia, Maryland, Pennsylvania, and New York, being totally absent. The evidence at hand seems to indicate that the Catskill beds were never deposited in the southern Appalachian States, since there is no vestige of their occurrence and the Pocono lies naturally upon the Chemung Series of the Devonian with little angular change in dip. At this contact zone, however, there is a very considerable faunal unconformity, but this is not nearly so great as has been previously supposed, since the writer has lately found in the undoubted Pocono various species (notably **Spirifer disjunctus**) which were not supposed to have survived beyond the Chemung and which will be discussed in a later volume of more general geographic scope than the present Report.

The absence of the Catskill Series in the southern counties is quite in harmony with the general aspect of the entire Devonian which rapidly thins out to the southward until at Chattanooga, Tennessee, it is almost, if not quite entirely, absent, there being a difference of opinion as to the age of the beds in the contact zone between the Mississippian and Silurian of that region. In the area under study the Chemung Series occurs with average thickness in eastern Monroe County but loses more than half its beds before reaching southwestern Mercer. The same statement is precisely true of the Portage Series, while the Genesee and Hamilton, coming just below the Portage, were recognized only in southeastern Monroe. The Marcellus Series is generally present in the region of its outcrop, although usually in somewhat attenuated form, but at its base there is a considerable disconformity, the Onondaga, Schoharie, and perhaps the Esopus of the New York column being apparently absent. The Oriskany Series is represented only by the Ridgeley Sandstone member and the underlying Helderberg only by somewhat infrequent occurrences of a remnant of the New Scotland Chert, which is a member that normally belongs in the upper half of a limestone group.

Beneath the New Scotland Chert, which is the basal Devonian bed of the three counties, there is another disconform-

ity of first rank, as well as a faunal break of large extent. Here the entire Salina Formation of the Silurian, including the Bossardville Limestone, Rondout Waterline, and Bloomsburg Red Shale, has completely disappeared, as has also the Niagara Limestone belonging below the Salina, so that the New Scotland, or the Oriskany as the case may be, of the Devonian, rests directly on the Clinton Series of comparatively early Silurian time. Most unfortunately these ancient beds have all been so much disturbed and crushed in the regions of their outcrops in both Mercer and Monroe Counties that little reliable evidence as to the angular relationship of their strata may be obtained. Farther down the White Medina (Tuscarora, Clinch) Series is always present at its proper horizon, although much abbreviated in thickness as compared to regions farther northeast, and the Red Medina (Juniata) Series is also constantly present but like the White has considerably thinned out. At the contact of the two there is much irregularity of bedding as is always the case where there is an abrupt change from older red beds to younger and heavy sandstones, but there is little evidence for belief that this was caused by other than diastrophic or littoral conditions, and in spite of the fact that many able geologists and important institutions have named this plane as the boundary between Silurian and Ordovician there is evidence for belief that no important time break occurred, the presence of **Arthrophycus** in both the White and the Red Medina, as found by Dr. Prouty and the writer on East River Mountain south of Bluefield, being a circumstance that lends a new aspect to this old question, since it is hardly probable that such a peculiar organism would cross the boundary between two periods and so far as known it has not been reported from the Ordovician.

At the base of the Red Medina and at the Silurian-Ordovician boundary there appears to be an unconformity of considerable scope. The Gray Medina, belonging just below the Red and being the basal formation of the Silurian as correlated in northeastern West Virginia, is almost entirely absent in the three counties, there being only one two-foot outcrop of rock in the Narrows of New River that has been doubt-

fully assigned to it. In the Martinsburg Series, coming below the horizon of the three Medinas and apparently agreed upon by all as being entirely within the Ordovician, certain important beds which appear at the top of the Maysville Group in Ohio, Kentucky, and elsewhere have not been observed in West Virginia, and there is further involved the possible absence of the Richmond Series. This latter, which in Ohio, Indiana, and Kentucky is described as occurring above the Maysville Group and as carrying an abundant marine fauna in some localities, has often been correlated with the Red Medina (Juniata) and as such has been sometimes placed in the Silurian and sometimes in the Ordovician. The subject of its correlation with the Red Medina is hardly pertinent under the present heading and its age is not of immediate moment. but the fact that its fauna appears to be wholly lacking in the area under study is suggestive evidence of an important time break at its place in the rock column.

Farther down in the Ordovician there appear to be several disconformities, there being no certain evidence that the Chambersburg Limestone, Tellico Sandstone, and Athens Shale are represented.

At the base of the Beekmantown, which is at the base of the Ordovician, there is, unfortunately, little evidence to show the magnitude of the unconformity that occurs. In parts of Mercer and Monroe Counties and in the Narrows of New River there is a series of dolomites and calcareous shales, 1,000 feet thick and lying entirely below any recognized Beekmantown fossils. Dr. Prouty and the writer have doubtfully assigned this formation to the Elbrook Limestone of Cambrian age, although there is no fossil evidence to support such an assumption. If this viewpoint is eventually sustained it is evident that the important Conococheague Limestone, belonging in the top of the Cambrian in some of the northeastern States and lying between the Beekmantown and Elbrook, is absent in Monroe and Mercer Counties. Aside from this uncertainty there is present the well-known time break at the Cambro-Silurian boundary at the bottom of the Beekmantown.

PLATE IX.—Upper ledge of Avis Limestone along Tallery Mountain road 1½ miles south of True, Summers County, looking north. Keeney Mountain in extreme background, capped mostly by Bluestone Group. Slopes in foreground made by Hinton Group. (Photo. by Palmer & Fowler).

FAULTS.

Faults occur in the southern portions of Mercer and Monroe Counties and consist almost entirely of overthrusts, there being one which passes entirely across both counties and several others of more local extent. In Summers County there is no displacement large enough to be mapped, although a few small breaks are evident.

Boissevain Fault.—The Boissevain Fault of Hennen[14] is an extensive break in the rocks which occurs in southwestern Mercer County, West Virginia, and in Tazewell County, Virginia, an earlier description having been made by Campbell[15] and another at a more recent date by Harnsberger[16] who mapped it through Tazewell County. As indicated by the latter, the fault starts in the vicinity of Doran west of Richlands, Tazewell County, where it branches from the more extensive Richlands (Hunter Valley) Fault, and extends northeastward approximately 32 miles across the county, entering Mercer County, West Virginia, at Wolfe, just northeast of Pocahontas. In the latter county it extends northeastward 2½ miles and apparently ends in the angle between the Pocahontas Syncline and Abbs Valley Anticline three-fourths mile east of Freeman.

In the vicinity of Richlands, Tazewell County, Harnsberger maps this fault as an overthrust from the east, the entire structure being overturned. Farther northeast toward the Mercer County line, however, the structure appears to regain an approximately vertical position on either side of the fault-line. On the west it quickly flattens out, indicating the presence of more competent strata or a diminishing force, but on the east it rises abruptly to the Abbs Valley Anticline, the latter being regarded as the northeastward extension of the Richlands (Hunter Valley) Fault which ceases to be an actual

[14]Ray V. Hennen, Wyoming and McDowell Report, W. Va. Geol. Survey, pp. 46-47; 1915.

[15]M. R. Campbell, Pocahontas Folio, No. 26, U. S. Geol. Survey; 1896.

[16]T. K. Harnsberger, The Geology and Coal Resources of the Coal-bearing Portion of Tazewell County, Virginia, Bull. XIX, Virginia Geol. Survey, p. 39; 1919.

break at the head of Abbs Valley in Tazewell County. At the locality of Cross-Section AA′, in Mercer County just east of Bramwell, there would appear to be a displacement of about 200 feet, the hade of the fault-plane being about 45 degrees west of the vertical, the strata from the east being thrust over that on the west. Northeast of the junction of the Pocahontas Syncline and Abbs Valley Anticline there is no apparent reflection of the break.

Graham Fault.—The Graham Fault of Campbell[17] is a supposed overthrust which has been mapped and in part described as starting on Indian Creek in Tazewell County, Virginia, about 1½ miles northeast of Cedar Bluff, and as extending northeastward, passing just north of Baptist Valley village, three-fourths mile north of Gap Store, just south of Tiptop and Bailey, one-half mile north of St. Clair, just south of Graham (now Bluefield, Virginia), and as entering Mercer County, West Virginia, slightly east of Graham, its approximate length in Tazewell County being 31 miles. In Mercer County it is mapped as passing through Bluefield, slightly south of Ada, one-half mile south of Ingleside, and as passing off the eastern edge of the old Pocahontas Folio about three miles east of Ingleside, the approximate length in Mercer County being indicated as 15 miles.

Along almost the entire length of this supposed fault the beds have been overturned and now dip southward at a sharp angle, and it has been indicated in the structural cross-sections of Campbell that the Kimberling (Chemung, Portage, etc.) of the Devonian has slid over the younger Price Sandstone (Pocono) and Pulaski (Maccrady) Shale and is now in contact with the Greenbrier, so that there is no outcrop of the Price (Pocono) and Pulaski (Maccrady) in the vicinity of the fault-plane as mapped.

The writer has traversed almost the entire length of this supposed fault and can find little evidence of its existence, except that at some localities the beds have been crushed and slightly distorted without much apparent covering of the Pocono and Maccrady outcrops. Just northwest of Baptist

[17]M. R. Campbell, Pocahontas Folio, No. 26, 1896; and Tazewell Folio, No. 44, 1897; U. S. Geol. Survey.

Valley there are fossils of Mississippian age in the upper part of the sandy strata which were mapped as Kimberling, these upper beds being the same as the Pocono of West Virginia and Pennsylvania and the Price of Virginia. Just northwest of this Pocono outcrop, it is true that no Maccrady (Pulaski) is visible and there may be a slight overthrust, but as Campbell says there was probably little of this formation deposited in this part of Tazewell County. At Bailey and St. Clair both the Maccrady and Pocono are visible, there being several zones of Mississippian fossils in the Pocono at the latter point. In the south edge of Graham there are Mississippian fossils in the sandy rocks south of the Greenbrier outcrop, no note having been made as to the presence or absence of the Maccrady. In Mercer County both the Maccrady and Pocono are well exposed in the vicinity of the Bluefield Post-office, there being fossils of Mississippian age in both series, and on a short southern branch of East River about one mile southwest of Ada both formations are visible, there being Mississippian fossils in the Pocono. Both formations are again visible in the cuts of the Norfolk & Western Railway just north of the mouth of Big Branch near the western end of Mills Valley 1.3 miles west of Blake, there being some evidence of crushing and distortion, however, at this exposure. Beyond the eastern limits of the old Pocahontas Folio the two formations may be seen in place at various points in eastern Mercer County, and in the narrows of New River south of Lurich, Giles County, Virginia, where the fault would clearly be expected, they are both visible, with Mississippian fossils in the Pocono, although at this point the shales of the Maccrady are apparently somewhat crushed. Farther east, where a prolongation of the fault might be expected, both formations were frequently noted across Monroe County, West Virginia.

In view of the above evidence the Graham Fault of Campbell is not indicated on the geologic map and cross-sections of Mercer County which accompany the present Report, there being insufficient data for the postulation of an actual overthrust along this supposed line of fracture. It appears probable that the former misinterpretation of the structure was largely caused by a failure to recognize the

Mississippian age of the upper beds mapped as Kimberling in Tazewell and Mercer Counties and by a further possibility that many of the Maccrady (Pulaski) exposures now visible may have been partly or wholly concealed by woods at the early date of the Tazewell and Pocahontas Folios, there being little evidence of other serious misconceptions of age or structure elsewhere in the portion of Mercer County covered by the Pocahontas Folio.

Stony Ridge Fault.—Along the Norfolk & Western Railway on Bluestone River just northwest of the mouth of Wright Valley Creek and only slightly northwest of the new Bluefield, Virginia, station which was completed in 1924, there is a plainly visible fault in Tazewell County where the river gap reveals the structure of Little Stone Ridge and Stony Ridge. Here, at the south side of the fault, the shales of the Bluefield Group of the Mauch Chunk, which are overturned and now stand at an angle of perhaps 70 to 80 degrees north of the vertical, appear to be thrust under a massive outcrop of the Stony Gap (Hinton of Stevenson) Sandstone, the latter being compressed into an arched structure. A few hundred feet to the northwest the rocks are again broken by a very evident fault, the downthrow being on the southeastern side and the top of the Stony Gap Sandstone being on an approximate level with the base of the Glenray Limestone of the Bluefield Group which is visible on the western side of the fault and which there dips northwestward at an angle of 40 degrees and is not overturned. The situation described is, in effect, a double underthrust from the southeast which is quite contrary to the usual Appalachian structure.

This fault has been indicated by Campbell on the Pocahontas Folio but has not been further described or named. As a matter of record the title of **Stony Ridge Fault** is here suggested. Campbell gives it a hypothetical extent of about 1½ miles from Bluestone River westward into Little Stone Ridge and toward the east he draws it little more than one-third of a mile, and there appears to be no evidence that it reaches into Mercer County.

St. Clair Fault.—The St. Clair Fault of Campbell[18] is an immense overthrust which crosses the southern ends of both Mercer and Monroe Counties. Concerning this fault Campbell makes the statement that it is "Far-reaching toward the southwest", and he appears to have mapped it across southwest Virginia almost to the Tennessee line in the Pocahontas, Tazewell, Bristol, and Estillville Folios, but the name is not carried on the maps, the descriptions are meager, and there are so many divergent branches in the general system of faults that its certain alignment may scarcely be followed. In Tazewell County, Virginia, however, this fault passes through Cedar Bluff, just south of Baptist Valley village, just north of Gap Store, about one-half mile south of Tiptop and Bailey, about one mile south of Graham (now Bluefield, Virginia) and enters Mercer County, West Virginia, on Beaver Pond Creek 1½ miles southeast of Graham.

In Mercer County it passes northeastward up the valley of Beaver Pond Creek, being slightly north of the creek itself except at the head, crosses Grassy Branch 0.8 mile above and southwest of its mouth, passes one-fourth mile north of Thompson School, and just north of Jarrell and Holt Schools, passes 0.4 mile south of McKenzie Station, crosses Pigeon Creek just south of Pigeon Creek School and Trimble Branch just north of Neel School, is exposed in the bluff just south of Wills Station, and crosses the line of Mercer County with Giles County, Virginia, one mile southward from Glenlyn. In Giles County it crosses New River in the narrows one mile south of Rich Creek Station, being well exposed on both sides of the valley, and enters Monroe County, West Virginia, on Scott Branch 1½ miles southeast of Peterstown.

In Monroe County it generally skirts the northern foothills of Peters Mountain for 19 miles, passing one-fourth mile north of Green Valley School, crossing Spruce Run just northwest of Spruce Run School, passing just north of Shires School and crossing Rock Camp Creek at Rock Camp School, passing just south of Zenith and one-half mile southeast of McGlone, or through Crimson Springs. Here it turns more

[18]M. R. Campbell, Pocahontas Folio, No. 26, U. S. Geol. Survey; 1896.

toward the north for two miles, crossing Turkey Creek 1¼ miles east of McGlone, until it reaches the southern base of Gap Mountain where it resumes its generally parallel position with respect to Peters Mountain, and for the remaining distance of 14 miles across the county it follows along the southern slope of Gap Mountain, passing through Gap Mills and three-fourths mile north of Centennial, passing one-third mile north of Coakesbury and one-half mile south of Cove Run School, and crossing the line of Monroe County with Alleghany County, Virginia, 1.2 miles northward from Sweet Springs.

The complete alignment of this fault is shown on Maps II and IV, and its structure is shown in Cross-Sections AA′, BB′, and CC′ in Mercer County, as engraved on the margin of Map II, and that in Monroe County is exhibited in Cross-Sections DD′, EE′, and FF′, as printed on Map IV. These maps and cross-sections show that its hade angle varies from 50 to 55 degrees north of the vertical, which is the approximate dip of the superincumbent strata on the southern side, and that the Beekmantown Limestone of the basal Ordovician is generally thrust over the Marcellus Shale of the Middle Devonian, there being certain exceptions. The thickness of Beekmantown exhibited on the south of the fault varies greatly, however, its minimum being about 1,000 feet while at some points, notably just southeast of Bluefield, there is approximately 3,500 feet, of which the lower 1,000 feet may be of Cambrian age, since there no fossils were found in this lower mass. On the northern side the rocks are much crushed and have been overturned to the approximate angle of the fault-plane.

In the extreme southwestern corner of Mercer County a branch fault departs from the main St. Clair Fault in South Bluefield just east of Bland Street and passing southwestward through the vicinity of the Country Club enters Tazewell County one-third mile northwest of Beaver Pond Spring. In the latter county it has been mapped by Campbell in the Pocahontas Folio as preserving an independent plane for about 2½ miles and as returning to the major plane 1½ miles southwest of Graham. This fault lies south of the main St. Clair

Fault and through its length of approximately four miles in Mercer and Tazewell Counties is never as much as one-half mile distant from the other. In Mercer County the zone between the two is occupied by a surface outcrop of Stones River (Chickamauga) Limestone of the Ordovician, inclined about 55 degrees north of the vertical as shown on Cross-Section AA'.

Sugar Grove Fault.—The Sugar Grove Fault, not previously named or described, is an overthrust of comparatively small proportions, located in the extreme southeastern corner of Monroe County. As shown on Map IV and on Cross-Section FF', this fault originates on the headwaters of Trout Run of Potts Creek 2½ miles southeast of Laurel Branch, and extends northeastward approximately parallel to Potts Mountain, passing Sugar Grove School and entering Craig County, Virginia, one-half mile farther northeast, its length in Monroe County being about three miles. Its further extent in Craig County has not been mapped but it appears to be reflected on Paint Bank Branch of Potts Creek about 1½ miles south of Paint Bank village.

Cross-Section FF', owing to its alignment near the western end of this fault does not show the more prominent features of this fault as they are displayed farther east near Sugar Grove School. At the latter locality the Martinsburg Series, lying on the north side of the break and dipping southward at about 30 degrees, is in contact with the Stones River (Chickamauga) Limestone which lies south of the fault and dips northward at an angle that varies from 40 to 60 degrees, and which is thrust northward over the Martinsburg, obscuring the intermediate Moccasin Limestone. The fault was evidently caused by the partial overturn and breakage of the northern limb of the Back Valley Anticline, the axis of which lies just to the southward. The plane of the fault appears to be inclined about 40 degrees north of the vertical.

Talcott Fault.—In the northern face of Wind Creek Mountain on the south side of Greenbrier River three-fourths mile southeast of Talcott, Summers County, a slight fault is visible in the Droop Sandstone of the Bluefield Group of the Mauch Chunk Series which is near the river level just east

of Talcott but rises rapidly eastward toward the Alderson Anticline until it is well up in the mountain at the point named. Looking southward from the Talcott-Lowell road north of the river, where the break may be seen to best advantage, there appears to be a vertical displacement of about 50 feet, the downthrow being on the western side of the fault-plane, so that the top of the thirty-foot cliff on that side is now below the base of the same member on the eastern side, the break being approximately vertical. West of the fault the sandstone has the normal northwestward dip but on the east side the dip is locally reversed, giving the impression that the strata east of the plane may have been forced upward while those on the west side had little movement. No further reflection of this fault was noted to the northward or southward where extensions might be expected, but a careful investigation was not made. As a matter of record this break is herein designated the **Talcott Fault,** its known extent being entirely too small to be indicated on Map VI.

CHAPTER V.

MEASURED SECTIONS.

INTRODUCTION.

The surface rocks of Mercer, Monroe, and Summers Counties embrace the Quaternary, with Recent and Pleistocene deposits, and a considerable portion of the Paleozoic, with Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, and possibly Cambrian sediments. A classification of all the beds named, involving approximately 19,300 feet of rocks, is published in Figure 6, on pages 130-133.

The Quaternary Rocks are represented by clays, gravels, and sand beds, present along the river and creek bottoms. and by river-terrace deposits of considerable quantity, some of which are of evident Pleistocene age, although not of glacial origin. These two types of comparatively young material are represented on Maps II, IV, and VI under the general title of Alluvium. As agricultural soil they form a valuable economic resource of the three counties. The terrace deposits have been discussed at length on pages 64-70.

The New River Group of the Pottsville Series of the Pennsylvanian, which is the youngest of the Paleozoic beds in any of the three counties, probably once covered the major portion of Summers County and considerable portions of Mercer and Monroe, but is now confined to a narrow and discontinuous strip along the northwestern and northen edges of Mercer and Summers, its conjectural extension toward the southeast having been eroded. Its present thickness in Mercer County apparently does not exceed 500 to 600 feet, or little more than half of its maximum in Fayette and other counties.

The Pocahontas Group of the Pottsville Series of the Pennsylvanian, lying below the New River and being the oldest rocks of this period in West Virginia, now occurs only in the northwestern part of Mercer County and in a narrow strip along the western part of Summers, and in certain small and discontinuous areas in the northern and eastern parts of the latter county, its former southeastern extent being problematical. Its thickness varies from 500 to 700 feet.

The Mauch Chunk Series of the Mississippian, containing the Bluestone, Princeton, Hinton, and Bluefield Groups, and comprising nearly 3,500 feet of sediments, forms the greater part of Summers County and covers large areas in both Mercer and Monroe. Its development in these three counties is the apparent maximum of the Appalachian region; and on account of its good exposure and abundant fossil content the opportunities for its study and correlation are unexcelled.

The Greenbrier Series of the Mississippian, containing about 1,800 feet of predominantly calcareous rocks in the three counties, outcrops in a belt which is narrow in southern Mercer County but which rapidly widens into a broad area in central and northern Monroe, there being only a small amount above drainage in Summers. This series, also, affords a most interesting display, but does not reach the maximum that can be measured in Washington County, Virginia.

The Maccrady and Pocono Series of the Mississippian outcrop both in southern Mercer and in portions of Monroe County. The Maccrady varies in thickness from 25 to 350 feet as compared to 700 feet or more at its type locality in Smyth County, Virginia. The Pocono, also, is decadent in character, being usually not more than 200 or 300 feet thick, although it attains 900 feet in eastern Monroe.

The Devonian outcrops in southern Mercer and southern and southeastern Monroe but is poorly represented, one of its major subdivisions (Catskill) being entirely absent and certain others being of sporadic occurrence or thin; and the entire assemblage is little more than 4,000 feet in thickness as compared to 11,000 feet along the Potomac River in northeastern West Virginia.

The Silurian Period, in the region of its full outcrops in southern Monroe County, is hardly more than 1,000 feet thick, several of its major subdivisions including the Salina and Niagara being entirely absent and some others being poorly represented.

In the Ordovician which outcrops both in southern Mercer and southern Monroe, nearly 5,000 feet of sediments have been recorded, while 1,000 feet more of non-fossiliferous, dolomitic limestone may also belong to it, although certain evidence favors the belief that the latter may be of Cambrian age. The Ordovician exposures are very complete and easily accessible in both counties.

In Summers County and in the gently dipping areas of northern Mercer and northwestern Monroe numerous vertical cross-sections have been measured to study and exhibit the details of the surface rocks; and in the steeply dipping or overturned beds of southern Mercer and southern Monroe additional sections have been obtained in gaps and other convenient localities where it was possible to determine approximately true vertical thicknesses by trigonometric computation. All of these various sections from the two regions appear in the following pages.

Many of these sections contain parenthetic references to Fossil Lot, or Locality, numbers indicative of collections made in the particular zone described. All plant fossil collections have been studied by Dr. David White, of the United States Geological Survey who also attended to part of the collection in the field, but the lists are not available in time for publication in the present Chapter and hence will be found, together with Dr. White's discussion, in Chapter XVII, to which the reader may readily refer by means of the Lot Number. Marine fossil collections in the Pennsylvanian and Mississippian, with only a few exceptions, have been studied by Dr. George H. Girty, of the United States Geological Survey, who also made some collections in the field, but the complete lists are not yet available and only the class names, together with some of the more important genera and species, are published in the sections of the present Chapter. The complete lists, with Dr. Girty's discussion, will be found in Chapter XVIII.

In the Devonian, Silurian, and Ordovician nearly all of the collections have been studied by Dr. Prouty of the Survey Staff who also gave personal attention to the collection of most of them in the field, as later detailed. These lists have been received in time for insertion in the measured sections which is accordingly done. Their further discussion by Dr. Prouty will be found in Chapter XVIII. In some instances fossils are recorded in the sections without attached lot numbers. All such lists are identifications made in the field by the writer without collections or reference to the three Paleontologists above named.

MEASURED SECTIONS, MERCER COUNTY.

Mercer County includes a large amount of comparatively flat-lying strata where direct vertical measurement of the rocks is possible, and also a considerable belt of tilted, faulted, and overturned beds in its southern portion. Its rocks range from the New River Group of the Pottsville Series of the Pennsylvanian down to the probable base of the Ordovician and possibly into the Cambrian, there being some doubt as to the propriety of assigning certain strata to the latter period. The portion of the county containing Pennsylvanian sediments and included in Rock and Jumping Branch Districts has been previously studied by C. E. Krebs and his assistant, D. D. Teets, Jr., who have published measured sections of this territory in the Report of the Survey on Raleigh County and the Western Portions of Mercer and Summers Counties, pages 81-85, inclusive, and pages 172-191, inclusive. No additional sections for these two districts have been measured for the present Report.

MEASURED SECTIONS, BEAVER POND DISTRICT, MERCER COUNTY.

Beaver Pond District occupies the extreme southern end of Mercer County, embracing the watershed between Bluestone and East Rivers. Its surface rocks range from the Bluestone Group of the Mauch Chunk Series down to the probable base of the Ordovician and possibly into the Cam-

brian. A large portion of this territory has been highly disturbed, with faulted and overturned strata, but in some localities the structure is of normal occurrence and gentle dip. The exposures at most points, however, are very good and there is little crushing or distortion except along the immediate lines of the faults and in the geographic zone immediately north of Stony Ridge where the overturned rocks suddenly revert to their normal succession.

The following short section, which was measured by the writer on the steep eastern slope of the Abbs Valley Anticline, is of principal interest because of the lenticular coal which divides the Glenray Limestone and because of the lenticular Edray Sandstone which occurs in the lower portion of the Lillydale Shale:

Nemours Station Section.

Beaver Pond District, Mercer County; starting at east end of Norfolk and Western Railway cut just west of Nemours Station and extending westward through cut in descending stratigraphic order; dip, southeast 70°; thicknesses measured by hand or estimated.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (217′)			
1. **Limestone, Reynolds,** gray, with marine fossils	3	3	3
2. **Shale, Bickett,** red and variegated	15	18	
3. **Sandstone, Webster Springs,** shaly	5	23	20
4. Limestone and gray shale, interstratified, **Glenray Limestone,** with marine fossils in limestone	25	48	
5. Shale, dark, fissile	2	50	
6. **Coal, Nemours** (type locality), (0′ 3″) (2305′ B.) (Exposure No. 792 on Map II)	..	50	27
7. Fire clay shale	2	52	
8. **Limestone, Glenray** (continued), shaly, with marine fossils	25	77	27
9. **Shale, Lillydale** ("Pencil Cave), (Menard age), dark, fissile	15	92	
10. **Shale, Lillydale** (continued), sandy	25	117	
11. **Shale, Lillydale** (continued), dark, fissile, with ferruginous nodules; contains numerous marine fossils, largely pelecypods, gastropods, and cephalopods (see **Lot 121**)	75	192	115
12. **Sandstone, Edray,** shaly, to west end of cut	25	217	

The following section, measured by the writer with some assistance by Paul H. Price, is located in Virginia along Bluestone River and near the Mercer County line and is of interest

because of its display of several members of the upper part of the Bluestone Group which here receive their names, the Falls Mills Sandstone being conspicuously displayed where it crosses the river:

Falls Mills Section.

Tazewell County, Virginia; in Clear Fork District; starting just south of Falls Mills Station and traversing northward along Norfolk and Western Railway in descending order; dip, southeast, about 21°; thicknesses measured by hand or estimated.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Princeton Conglomerate (30′)				
1.	**Sandstone, Princeton,** massive, coarse, pebbly, with plant fossils	30	30	30
Mauch Chunk Series—Hinton Group (592′)				
2.	**Shales, Terry** and **Pluto,** partly concealed	50	80	
3.	Sandstone, very shaly	15	95	
4.	**Shale, Lower Pluto,** sandy, partly concealed	80	175	
5.	**Sandstone, Falls Mills** (type locality), green, flaggy, makes natural dam at old mill	40	215	185
6.	**Shale, Falls Mills** (type locality), red and variegated (2330′ B.); contains marine fossils at top, pelecypods (especially **Myalina**) and many ostracods (see **Lot 249**)	50	265	
7.	Sandstone, shaly	15	280	
8.	Shale and concealed	30	310	
9.	Sandstone, shaly	15	325	
10.	Slate, dark	2	327	
11.	**Limestone, Falls Mills** (type locality), shaly (2330′ B); contains marine fossils, small pelecypods and abundant ostracods (see **Lot 250**)	5	332	117
12.	Sandstone, shaly	15	347	
13.	**Shale, Upper Fivemile,** gray, sandy	15	362	
14.	**Sandstone, Tallery,** shaly	7	369	
15.	Shale, sandy	5	374	
16.	**Limestone, Tallery,** shaly, with marine fossils	2	376	
17.	**Shale, Upper Tallery,** sandy, fissile	15	391	
18.	**Sandstone, Low Gap,** shaly	10	401	69
19.	Concealed and red shale	200	601	
20.	**Sandstone, Hackett,** shaly	20	621	
21.	Limestone, shaly	1	622	
22.	Shale, variegated	..	...	

The following section, measured primarily by the writer, with additional inspection and field comment by Drs. David White, George H. Girty, and W. F. Prouty and Mr. Paul H. Price, who all assisted in certain of the fossil collections as

later detailed, shows the relationship of the Graham Coal at its type locality to some of the basal members of the Bluestone Group. The writer is much inclined to believe that the coal and attendant sandstone and shale are the same as the Big Spruce Knob stage in Pocahontas County, as recorded in the Webster County Report, but as a safeguard against a possible misinterpretation it has seemed better to supplant, for the time being at least, the former titles:

Graham Section.

Tazewell County, Virginia; in Clear Fork District; starting 0.8 mile northwest of Graham (now Bluefield, Virginia) and traversing southeastward in descending stratigraphic order along Norfolk and Western Railway; dip, northwestward about 30°; length of traverse about 0.3 mile; thicknesses measured by hand or estimated.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (656′)				
1.	**Sandstone, Graham** (type locality), (probably same as **Big Spruce Knob Sandstone** of Webster County Report), shaly.....	15	15	15
2.	Shale, dark-gray, sandy	10	25	
3.	**Limestone, Graham** (type locality), shaly, with marine fossils..... 2′			
4.	**Shale, Upper Graham** (type locality), gray, ferruginous and limy, with numerous marine fossils 10			
5.	**Shale, Upper Graham** (continued), sandy, with marine fossils..... 5	See **Lot 123**, collected from Nos. 3, 4, and 5; contains some brachiopods, but chiefly pelecypods and gastropods	17	42
6.	**Shale, Upper Graham** (continued), dark, fissile, with plant and marine fossils ..... 4′			
7.	**Coal, Graham** (probably same as **Big Spruce Knob Coal** of Webster County Report), soft, slaty (2365′ B.) (Exposure No. 770 on Map II) 1	See **Lot 124** for plant fossils collected from Nos. 6 and 9	25	67
8.	Fire clay shale, gray.....15			
9.	**Sandstone, Bertha**, shaly, with plant fossils..... 5			
10.	Shale, gray		3	70
11.	**Limestone, Bertha**, shaly.....		2	72	57

		Thickness. Feet.		Total. Feet.	Intervals. Feet.
12.	Shale, variegated.....10′				
13.	Sandstone, massive..... 5				
14.	Shale, sandy 5		Lower Bertha		
15.	Sandstone, massive..... 4		Shale 44	116	
16.	Shale, red and variegated, with sandstone.....20				
17.	**Sandstone, Bradshaw,** shaly.....	10		126	54
18.	**Shale, Bradshaw,** red and variegated, and concealed	75		201	
19.	**Sandstone, Indian Mills,** mostly massive..	40		241	115
20.	Shale, red and variegated, partly concealed across river 300			541	
21.	**Limestone, Glenray,** shaly, to **Stony Ridge Fault-plane** just west of junction with Clinch Valley Division; contains marine fossils (see **Lot 14**) 115			656	

The following section, measured by the writer, indicates the nature of the contact between the Mauch Chunk and Greenbrier Series along the foot of Stony Ridge between the two Bluefields. A peculiarity of this region is that the Glenray Limestone which should occupy the position of No. 1 of section, is entirely replaced by sandy shale, as is also the case on the Bluefield-Princeton road south of Stony Gap as will be later detailed:

Waugh Siding Section.

Beaver Pond District, Mercer County; on Crenshaw Branch of Bluestone River 1.2 miles west of Bluefield, West Virginia, Station; traverse from north to south in descending order across overturned strata; average dip, 50° southeastward; total length of traverse, 500 feet.

		Thickness. Feet.		Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (220′)					
1.	Shale, sandy, from north end of cut.....100			100	
2.	**Shale, Lillydale ("Pencil Cave"),** dark, fissile.....120			220	
Greenbrier Series (175′)					
3.	Limestone, flaggy and shaly .....60′				
4.	Shale, calcareous, with lenses of very fossiliferous limestone, crinoids, etc. 35		Alderson Limestone 175	395	
5.	Concealed and limestone, shaly, to N. & W. Ry. (2505′ B.).....80				

The following section, measured by the writer, is located in the middle of the city of Bluefield, West Virginia,

PLATE X.—Goodwyn Sandstone at type locality on Fivemile Creek opposite Goodwyn Chapel, Mercer County, looking north up creek. Bedding is natural and dip northwest toward Hurricane Ridge Syncline. Underlying shales are visible below sandstone. (Photo. by Palmer & Fowler).

some of the best exposures having now been covered by buildings which were fortunately at the favorable excavation stage when part of the observations were made. The collections at Lots 1 and 2 were principally made by Dr. Prouty who studied them under the misapprehension that they belonged in the Devonian as had been indicated by the former mapping of the Pocahontas Folio. When the Mississippian ge of these beds became known through the identifications of Dr. Prouty, and the still earlier but apparently unpublished collections of Dr. Girty near the same spot, the writer made a more detailed inspection and found not only the fucoid **Taonurus caudi galli,** which is common in the New Providence of Kentucky and the Grainger of Tennessee (both of Pocono age), but also found the Sunbury Shale with it **Lingula** and **Orbiculoidea,** the latter formation having been, in the meantime, revealed by a new excavation. These various discoveries naturally make the section one of much importance in the more extended correlation of the lower part of the Mississippian:

Bluefield Section.

Beaver Pond District, Mercer County; starting with east and west line just north of Bluefield Municipal Building and traversing southward mainly along Bland Street about 3,000 feet; strata overturned and now dipping southeastward 35° to 65°; arrangement in descending stratigraphic order; thicknesses estimated from pacing vertical angles.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Greenbrier Series ( )			
1. Limestone, cavernous, reported in excavation for basement of West Virginian Hotel; now covered	..	...	
Maccrady Series (265′)			
2. Concealed, and yellow, calcareous shale, with marine fossils. **Lot 1,** in excavation on Federal Street just southwest of West Virginian Hotel and just north of Peery Building; contains **Spirifer** close to **bifurcatus, Fenestella** cf. **tenax, Nucula** sp.	150	150	150
3. Shale, red	50	200	
4. Shale, yellow, calcareous	30	230	
5. Sandstone, reddish-brown, coarse, friable, with abundant plant fossils; exposed behind buildings on west side of Bland Street	5	235	
6. Shale, yellow, sandy	30	265	

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Pocono Series (390′)			
7. Sandstone, brown, friable	20	285	135
8. **Sandstone, Broad Ford,** reddish-brown, friable; contains marine and plant fossils; brachiopods, crinoids, fucoids	20	305	
9. Shale, yellow, sandy, friable, **Broad Ford Sandstone horizon** (continued)	20	325	
10. **Sandstone, Broad Ford** (continued), brown, friable, with fucoids (**Taonurus caudi galli**)	10	335	
11. **Sandstone, Broad Ford** (continued), reddish-brown, or brick red, hard but weathering friable, with streaks of shale and with marine fossils. **Lot 2** in excavation for basement of Bailey Building southeast of Post-Office; contains **Camarotoechia** sp., **Fenestella** (several species); [also crinoids, gastropods and other brachiopods (**Chonetes**) which were not collected—D. B. R.]	100	435	150
12. Sandstone, with quartz pebbles, only a streak visible		435	
13. Concealed	100	535	
14. Shale, greenish-gray, sandy, friable	100	635	200
15. **Shale, Sunbury,** dark, argillaceous, and carbonaceous (2575′ B.); contains marine fossils, brachiopods (**Lingula** and **Orbiculoidea**) (see **Lot 296,** collected on east side of Bland Street about 800 feet south of Post-Office)	20	655	
Chemung and Portage Series (950′)			
16. Shale, **Chemung,** green, weathering yellowish-brown, chunky; contains marine fossils near base, brachiopods (**Camarotoechia?**)	100	775	
17. Sandstone, **Chemung,** green, flaggy, hard; and olive-green shale; to intersection of Bland and Wilson Streets	50	805	170
18. Sandstones, green and flaggy, and green shales; partly **Chemung** but apparently having some **Portage** and possibly **Genesee** toward the base; poorly exposed and not examined in detail; estimated	800	1605	
Marcellus Series (50′)			
19. Shale, black, fissile, crushed and metamorphosed, poorly exposed, 25′ to	50	1655	
20. **St. Clair Fault**		....	

The following section was measured by Paul H. Price and the writer in a gap which Beaver Pond Creek makes through a low ridge just south of the Bluefield Fairgrounds and near the line between Tazewell and Mercer Counties. At a previous date Dr. Prouty made a collection at Lot 38 but apparently the species had become so mixed through

slumping of loose material in the nearly vertical beds that the identifications were not considered as valuable. The Clinton Series is so metamorphosed that only a few fossil fragments could be found:

Bluefield Fair-Grounds Section.

Tazewell County, Virginia; on east side of Beaver Pond Creek just southeast of main entrance to Bluefield Fair-Grounds; rocks overturned and now dipping southeastward 70°; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Marcellus Series ( )		
1. Shale, black, fissile, not measured..... ..	...	
Oriskany Sandstone (130')		
2. Sandstone, gray and brown, pebbly, soft, and also cherty, with marine fossils (2435' B.). **Lot 38;** collection made in loose material mixed with Helderberg species, and therefore not reported..	130	130
Helderberg Limestone (235')		
3. Limestone, cherty, poorly exposed; contains marine fossils, crinoids, etc.....	235	365
Clinton Series (540')		
4. Concealed, with red sandstone having grains of white silica; a few marine fossils.....	160	525
5. **Sandstone, Keefer,** gray, hard, with quartz pebbles.	115	640
6. Concealed, with red sandstone; contains marine fossils, brachiopods	265	905
7. **St. Clair Fault,** followed by **Stones River (Chickamauga Limestone)**	...	

The following section was measured by the writer, the location of its disconnected but entirely successive parts being noted in its explanatory text, but certain of the fossil collections in the Mauch Chunk and the top of the Greenbrier were made with the assistance of Drs. David White and George H. Girty and Mr. Paul H. Price, as detailed in the List of Fossil Localities in Chapter XVII:

Stony Gap Section.

Beaver Pond District, Mercer County; starting at top of knob on eastward extension of Big Ridge 1 mile south of Belcher School; Nos. 1-24, inclusive, were measured with aneroid down the highway northward to Brush Creek just southwest of Princeton, there being a gentle eastward dip; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluestone Group (620′)				
1.	Concealed, with shale	15	15	
2.	Sandstone, green, flaggy. 30′			
3.	Concealed, with yellowish-green shale. 20	**Bent Sandstone** 70	85	85
4.	Sandstone, massive. 20			
5.	Shale, red (contains exposure of **Hunt Coal** on road north of Billie)	65	150	
6.	**Sandstone, Hunt,** shaly	15	165	
7.	**Shale, Hunt,** red and variegated	35	200	
8.	**Sandstone, Bratton** (type locality),	5	205	
9.	Fire clay shale, streak	..	205	
10.	**Shale, Bratton** (type locality), red	35	240	
11.	**Sandstone, Upper Belcher** (type locality), massive	15	255	170
12.	Shale, red and sandy. 10′			
13.	Fire clay shale, carbonaceous 2	**Upper Belcher Shale** (type locality) 30	285	
14.	Shale, red. 18			
15.	Sandstone, massive. 25′			
16.	Shale, red and sandy. 5	**Lower Belcher Sandstone**		
17.	Sandstone, massive. 10	(type locality) 40	325	70
18.	**Shale, Lower Belcher** (type locality), red	15	340	
19.	**Sandstone, Upper Mud,** shaly	5	345	
20.	**Shale, Upper Mud,** red, partly concealed	50	395	
21.	**Shale, Lower Mud,** dark-green, sandy	40	435	
22.	**Sandstone, Glady Fork,** massive	35	470	145
23.	**Shale, Pipestem,** dark-green sandy, to glade at Brush Creek	50	520	
24.	**Shale, Pride,** approximate thickness from drill holes	100	620	
	Section continued, starting with outcrop of Princeton Conglomerate on Bluefield-Princeton road 0.4 mile northeast of Stony Gap and traversing southwestward along the highway approximately 4,200 feet to a point 0.5 mile southwest of Stony Gap; strata overturned and dipping steeply southeastward:			
Mauch Chunk Series—Princeton Conglomerate (40′)				
25.	**Sandstone, Princeton,** gray, massive, very hard, with quartz pebbles	40	660	190
Mauch Chunk Series—Hinton Group (1330′)				
26.	Concealed	65	725	
27.	Sandstone	5	730	
28.	Concealed	118	848	
29.	**Sandstone, Falls Mills,** green, massive, with plant fossils at base	15	863	203
30.	Shale, dark-green; contains marine fossils, pelecypods and ostracods. 5′	**Falls Mills.** 15	878	
31.	Shale, red. 10			
32.	Sandstone, shaly	7	885	
33.	**Shale, Upper Fivemile,** red and variegated	15	900	
34.	Sandstone, shaly	5	905	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
35.	**Shale, Lower Fivemile,** red	10	915	
36.	**Sandstone, Tallery,** massive, streaked with shale	10	925	62
37.	**Shale, Upper Tallery,** sandy	20	945	
38.	**Sandstone, Low Gap,** shaly	5	950	
39.	**Shale, Low Gap,** green and sandy	35	985	
40.	**Sandstone, Avis,** massive	5	990	
41.	Shale, variegated	72	1062	
42.	**Shale, Upper Avis,** yellow; contains marine fossils, pelecypods, crinoids, and brachiopods	15	1077	
43.	**Limestone, Avis,** very shaly, much weathered; contains marine fossils, pelecypods, brachiopods (**Orthotetes, Diaphragmus,** etc.), and bryozoa	10	1087	162
44.	Shale, red	80	1167	
45.	**Sandstone, Hackett,** gray, coarse, hard	15	1182	95
46.	Shale, red and concealed.33′			
47.	Shale, red and variegated, with streaks of sandstone .....210 } **Hackett**	243	1425	
48.	**Sandstone, Tophet,** greenish-brown	10	1435	253
49.	**Shale, Upper Tophet,** etc., red, sandy and variegated	130	1565	
50.	Concealed, with shale	80	1645	
51.	Shale, green, sandy	60	1705	
52.	Concealed across gap	170	1875	
53.	**Sandstone, Stony Gap** (type locality), (**Hinton Sandstone** of Stevenson), white, hard, coarse, quartzitic, makes vertical cliff; contains plant fossils at base (see **Lot 235**)	115	1990	555
Mauch Chunk Series—Bluefield Group (1248′)				
54.	**Shale, Coney,** red and variegated, sandy, contains marine fossils, pelecypods (mostly **Myalina**), and ostracods (see **Lot 207**)	10	2000	
55.	**Shale, Coney** (continued), red and variegated, with sandy streaks	85	2085	
56.	**Sandstone, Clayton,** massive	5	2090	100
57.	Shale, variegated.....50′			
58.	Sandstone, shaly..... 5 } **Clayton Shale.**	95	2185	
59.	Shale, red and variegated.40			
60.	**Sandstone, Graham,** green, flaggy	33	2218	128
61.	Shale, green, horizon of **Graham Limestone.**	15	2233	
62.	Concealed, with red shale	72	2305	
63.	**Shale, Upper Graham,** sandy; contains marine fossils, pelecypods (especially **Sphenotus** and **Myalina**) and ostracods (see **Lot 208**)	30	2335	
64.	**Shale, Upper Graham** (continued) (probably same as **Big Spruce Knob Shale** of Webster County Report), dark, carbonaceous; contains plant fossils (see **Lot 234**)	10	2345	
65.	**Coal, Graham,** (0′ 6″), (2500′ B.), (**Exposure No. 773 on Map II**), (probably same as **Big Spruce Knob Coal** of Webster County Report)	0½	2345½	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
66.	**Shale, Lower Graham,** dark	4½	2350	
67.	**Sandstone, Bertha,** white, hard	20	2370	152
68.	**Shale, Upper Bertha,** sandy	40	2410	
69.	**Shale, Upper Bertha** (continued), dark, fissile, carbonaceous	5	2415	
70.	Shale, sandy, with a little sandstone	40	2455	
71.	Shale, variegated	30	2485	
72.	**Shale, Lower Bertha,** green, sandy; contains marine fossils, pelecypods	88	2573	
73.	**Sandstone, Bradshaw,** gray, much weathered, ripple-marked	15	2588	218
74.	**Shale, Bradshaw,** sandy	2	2590	
75.	**Coal blossom, Red Sulphur,** (2490′) (**Exposure No. 774 on Map II**)	..	2590	
76.	Concealed, with shale	15	2605	
77.	**Sandstone, Indian Mills,** much weathered	100	2705	117
78.	Concealed	220	2925	
79.	Shale, sandy	25	2950	
80.	**Sandstone, Droop,** much weathered and shaly; carries iron pyrites	20	2970	265
81.	**Shale, Ada,** green and fissile at top, calcareous at base (this portion is probably **Reynolds Limestone**); contains marine fossils, chiefly fenestelloid bryozoa, and some brachiopods (see **Lot 120**)	78	3048	
82.	**Shale, Lillydale ("Pencil Cave"), (Menard** age), green and fissile at top, black and fissile with lenses of iron carbonate at base	190	3238	268
Greenbrier Series (1795′)				
83.	**Limestone, Alderson (Glen Dean** age), gray, shaly, with a few dark, granular streaks containing profuse marine fossils, with brachiopods, bryozoa (**Archimedes**), horn corals, and crinoids (see **Lot 119,** collected over total outcrop); also contains zone of abundant plant fossils at base (2240′ B.) (see **Lot 128**)	110	3348	
	Section continued, offsetting from this point northeastward about 1300′ along the strike to the same plant fossil zone in a road which passes from Stony Gap southward to the N. & W. Ry., and thence traversing southeastward across the railway and up the first ravine east of the Bluefield Water Plant; strata overturned and dipping steeply southeastward:			
84.	**Limestone, Alderson** (continued), yellow, shaly; contains plant fossils at top and marine fossils in lower portion, mostly bryozoa with some brachiopods (see **Lot 118**)	67	3415	
85.	**Limestone, Alderson** (continued), yellow and sandy; contains numerous marine fossils, mostly bryozoa (including **Archimedes**), also brachiopods and crinoids (see **Lot 117**)	156	3571	333

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
86.	**Limestone, Union** (Gasper and **Fredonia** age), dark, weathering yellow; upper 50-foot portion has been quarried; N. & W. Ry. cuts through lower portion, which is slightly oolitic; contains marine fossils, blastoids (**Pentremites**), brachiopods, crinoids, and horn corals (see **Lot 116**, collected across outcrop, and **Lot 295**, collected from **Fredonia** portion along railroad	262	3833	
87.	**Limestone, Pickaway,** blue with 10′ of shaly calcareous sandstone at top, and with a little black, nodular chert at base; upper 75 feet once quarried on Ward Bailey land just south of railway; contains marine fossils throughout, bryozoa, brachiopods, crinoids, horn corals, and gastropods (see **Lot 115**)	258	4091	
88.	**Limestone, Pickaway** (continued), yellow, very sandy; contains bryozoa and numerous brachiopods (see **Lot 114**)	160	4251	
89.	**Limestone, Taggard,** gray, oolitic	5	4256	685
90.	**Limestone, Patton,** shaly, weathering yellow, with streaks of sandy shale and shaly sandstone; calcareous portions carry marine fossils, brachiopods, crinoids, and some bryozoa (see **Lot 113**)	234	4490	
91.	**Limestone, Sinks Grove,** blue, hard, with great amount of nodular, black chert; contains marine fossils throughout, brachiopods (including numerous **Orthotetes**) (see **Lot 112**)	300	4790	
92.	**Limestone, Sinks Grove** (continued), and **Hillsdale,** blue, shaly at top; contain nodular black chert and marine fossils in lower portion, brachiopods, bryozoa, and crinoids (see **Lot 111**)	243	5033	777
Maccrady Series (132′)				
93.	Limestone and calcareous shale	20	5053	
94.	Shale, red, and concealed	112	5165	
Pocono Series (318′)				
95.	**Sandstone, Broad Ford,** mostly reddish-brown thick-bedded, hard; contains plant fossils (ferns) in a loose boulder (see **Lot 110**); and also contains marine fossils at base, crinoids, brachiopods (**Chonetes**, etc.) and a long gastropod (?) or cephalopod (?) (see **Lot 294**)	218	5383	
96.	Sandstone, greenish-gray, thick-bedded, hard	100	5483	450
Chemung Series (110′)				
97.	**Sandstone, Hendricks,** (?), greenish-gray, weathering rusty-brown, with quartz pebbles at top; contains marine fossils, large pelecypods, brachiopods (**Spirifer**, etc.)	100	5593	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
98.	Sandstone, green, flaggy, interlaminated with olive-green shales of Chemung type, and with fucoidal (?) markings and marine fossils, crinoids; exposed just south of cottage standing at forks of hollow; not measured	..	....	

The section as above recorded gives the entire succession of the Mississippian with the exception of 250 or 300 feet of eroded beds at the top of the Bluestone Group and is of supreme importance not only with respect to an understanding of these rocks in the three counties under discussion but also in its application to their extended correlation, since there is no other point east of the Cincinnati Anticline where such a complete view may be obtained if both thickness and fossil content are considered. It is quite true that exposures of the Mississippian which are almost, if not quite, as thick may be seen in northeastern Pennsylvania but these latter appear to be totally barren of marine fossils and the important Greenbrier and Maccrady Series are totally absent, while at Stony Gap the Mauch Chunk Series appears to be near its maximum and at the same time reveals many plant and marine fossil horizons; and the Greenbrier is also not far from its maximum and contains a most interesting fauna and flora. It is a matter of regret that a better zoning of the marine fossil collections in the lower part of the Greenbrier is not available, but these were made when only a few of the significant minor contacts of the series in the three counties had been recognized. At this locality, also, the Maccrady Series has only a fair development and the Pocono is abbreviated by disconformities at its top and base although one of its important faunal zones may still be seen.

The following section, partly measured and partly estimated by the writer in the company of Dr. Prouty, who studied the joint collections at Lots 41, 42, and 43, indicates the nature of the lower portion of the Mississippian and the top of the Devonian in the East River Valley. The contact of the Pocono with the Chemung is not quite plain, however, and it may be possible that it belongs in the concealed interval of No. 10, although the recorded interpretation is favored by the lithology of the beds:

Blake Section.

Beaver Pond District, Mercer County; starting in gap of East River at end of Pine Ridge 1.5 miles west of Blake and traversing eastward along Norfolk and Western Railway approximately 3,600 feet across overturned strata; actual dip southeastward varying from 50° to 65°; thicknesses measured by hand or estimated; arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Maccrady Series (10′)			
1. Concealed, with red soil, in broken zone....	..	..	..
2. Shale, variegated	10	10	10
Pocono Series (70′)			
3. Shale, sandy	5	15	
4. Shale, dark, fissile, carbonaceous.....	5	20	10
5. Shale, sandy, and sandstone.....	50	70	
6. Shale, gray, fissile.....	10	80	60
Chemung Series (542′)			
7. Sandstone	6	86	
8. Sandstone, conglomeratic, with marine fossils	1	87	
9. Shales and sandstone, greenish-brown, with marine fossils. **Lot 43**; contains **Bellerophon** sp., probably new species, **Productella** sp., cf. **Spathella** sp., close to **S. typica, Chonetes** sp.....	75	162	
10. Concealed 100		262	
11. Sandstone, with quartz pebbles and marine fossils. **Lot 42**; contains **Bellerophon** sp., probably **B. clarki** C. & S., **Spirifer** cf. **marcyi** var. **superstes** C. & S., **Spirifer mucronatus** var., cf. **Craniella hamiltoniae** Hall, **Grammysia** sp., **Chonetes** sp.....	10	272	192
12. Shale, reddish-brown	50	322	
13. Sandstone, greenish, medium-grained, flaggy, with beds of shale and marine fossils. **Lot 41**; contains **Camarotoechia congregata** var. **parkheadensis** C. & S.., **Productella** sp., **Chonetes** sp., cf., **Hyolithes aclis** Hall, **Bellerophon** sp. Also **Lot 40**, at lower level; contains **Camarotoechia congregata** var. **parkheadensis** C. & S., **Leiopteria** cf. **bigsbyi** Hall, crinoid stems.....300		622	350

MEASURED SECTIONS, EAST RIVER DISTRICT, MERCER COUNTY.

East River District occupies the southeastern corner of Mercer County principally along the watershed of East River, its surface rocks ranging from the Bluestone Group of the Mauch Chunk Series of the Mississippian down nearly to the base of the Ordovician. A very considerable portion of this area has been highly disturbed, with overthrust faulting and

consequent overturn of the strata but in the northern part the rocks have only gentle dips, without faults or overturns. There is much slumping of loose material over the face of the strata in this portion of the district, however, so that opportunities for making good vertical sections are rare, while in the other, or southern, half the alignment of the tributaries which cut across the highly folded rocks is generally unfavorable for dependable work. A much better opportunity is afforded in the adjoining region of Giles County, Virginia, the northern end of which occupies the narrows of New River where there are unusually good exposures and where some very good sections were obtained.

The following section, measured by the writer, shows a considerable local thinning of the Pocono and Chemung Series, since it starts at only a short interval below the base of the Greenbrier Series, there being a concealed interval at the approximate horizon of the Maccrady:

Pigeon Creek Section.

East River District, Mercer County; starting just south of forks of Pigeon Creek, 0.8 mile southeast of Oakvale, and traversing southward to St. Clair Fault, approximately 4,100 feet; strata overturned and now dipping southeastward; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Pocono and Chemung Series (658′)		
1. Concealed and flaggy sandstone	88	88
2. Sandstone, massive, conglomeratic	50	138
3. Sandstone, mostly heavy flags, with thin beds of shale, partly concealed	310	448
4. Sandstone, geenish, flaggy, with thin beds of shale and marine fossils	210	658
Portage Series (803′)		
5. Sandstone, green, flaggy, with thin beds of shale	175	833
6. Shale, green, sandy, with thin flagstones	628	1461
Marcellus Series (90′)		
7. Shale, black, fissile, slickensided and metamorphosed	90	1551
8. **St. Clair Fault,** followed by dolomite	..	....

The following section, measured or partly estimated by the writer in the edge of Giles County, shows most of the lower half of the Bluefield Group of the Mauch Chunk Series as it occurs along a steep hill road south of Glenlyn:

Glenlyn Section.

Giles County, Virginia; starting at Glenlyn Station on Norfolk and Western Railway and ascending hill southeastward to point where highway crosses Virginian Railway 0.4 mile southeast of Glenlyn; strata overturned and now dipping steeply southeastward: thicknesses partly estimated; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (510′)				
1.	Concealed and variegated shale	100	100	
2.	**Sandstone, Indian Mills,** gray, coarse, massive	20	120	120
3.	Shale, red, and concealed	200	320	
4.	**Shale, Ada,** olive-green, calcareous, with marine fossil fragments	50	370	
5.	**Limestone, Reynolds,** shaly, with marine fossils, brachiopods	15	385	265
6.	**Shale, Bickett,** sandy	10	395	
7.	**Sandstone, Webster Springs,** flaggy	10	405	
8.	Shale, sandy, and concealed	25	430	
9.	**Limestone, Glenray (Menard** age), shaly, with marine fossils, bryozoa	10	440	
10.	Shale, red	20	460	75
11.	**Shale, Lillydale (Menard** age), **("Pencil Cave"),** dark, sandy, in Virginian Railway cut	50	510	

The following section, measured by the writer, principally in the company of Dr. Prouty while Fossil Lots 15-21, inclusive, were being collected, but further inspected in part by Dr. David White and Paul H. Price during the collection of Lots 231-233, inclusive, shows the strata for 1½ miles on the west side of New River at the northern end of the narrows. Attention is called to the fact that the first 29 numbers of the section are arranged in **descending order,** while the remainder are in **ascending order,** the rocks being overturned on the north side of the St. Clair Fault but occupying their normal position on the south side, so that no continuous succession of the present position of the strata can be recorded without a reversal in the order. Among other things the section shows three plant fossil zones in the Greenbrier Series, one of which, No. 16 of section in the middle of the Patton Limestone, was not elsewhere noted. All the marine fossil lots, Nos. 15-21, inclusive, were studied by Dr. Prouty, since the Mississippian age of Lot 15 was not suspected until after it had received laboratory attention and it was accordingly never sent to Dr. Girty:

Lurich Section.

Giles County, Virginia; on west side of New River starting near shanty about one-fourth mile southeast of Lurich and traversing southeastward along highway to railroad crossing and thence southeastward along Norfolk and Western Railway approximately 8,000 feet; measured by pacing and computation; strata in Nos. 1-29 dip southeastward and are overturned, their arrangement in the section being in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (837′)				
1.	Shale, variegated and sandy	..	...	
2.	**Limestone, Graham?**, with marine fossils (1605′ B.)	4	4	4
3.	**Shale, Upper Graham**, sandy	60	64	
4.	**Limestone, Bertha?**, gray, hard	5	69	
5.	Shale, and concealed	80	149	
6.	Shale, sandy	93	242	
7.	Concealed, calcareous soil	330	572	568
8.	**Limestone, Glenray (Manard age?)**, shaly, with marine fossils, to N. & W. Ry. crossing	120	692	
9.	Concealed, **Lillydale Shale** horizon ("**Pencil Cave**") (**Menard** age)	145	837	265
Greenbrier Series (1721′)				
10.	Concealed, with shale	155	992	
11.	**Limestone, Alderson**, shaly, with marine and plant fossils. (See **Lot 233** from plants..	5	997	
12.	Concealed, with calcareous shale, **Alderson** and **Union Limestones**	390	1387	
13.	**Limestone, Union**, gray, hard, with marine fossils; also cherty at base	175	1562	725
14.	**Limestone, Pickaway**, partly concealed	200	1762	
15.	**Limestones, Pickaway** and **Patton**, gray, hard, contain marine fossils, crinoids, brachiopods, blastoids (**Pentremites**), etc	406	2168	
16.	**Limestone, Patton**, shaly, with plant fossils (see **Lot 232**)	2	2170	
17.	**Limestone, Patton** (continued), gray, hard, with marine fossils	115	2285	
18.	**Shale, Patton**, calcareous, with plant fossils (see **Lot 231**)	15	2300	738
19.	**Limestone, Sinks Grove**, hard, with marine fossils	38	2338	
20.	Sandstone, shaly and calcareous	40	2378	
21.	**Limestones, Sinks Grove** and **Hillsdale**, gray, hard, cherty; contain marine fossils, crinoids, bryozoa, brachiopods, blastoids (**Pentremites**), etc	180	2558	258
	Total	..	2558	
22.	Concealed along zone of broken and disturbed rocks (425 feet horizontal measure) with some red, **Maccrady Shale**; thickness uncertain	..	....	

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Pocono Series (298′)			
23. **Sandstone, Broad Ford,** reddish-brown, coarse at top, shaly at base, some quartz pebbles near base; thin zones of marine fossils. **Lot 15;** contains **Camarotoechia** cf. **contracta** Hall, **Spirifer** sp., **Fenestella** sp., pelecypod sp., **Productus** cf. **semireticulatus** Martin	108	108	
24. **Shale, Sunbury,** brown, sandy, fissile	65	173	
25. Shale and sandstone, interlaminated, no fossils found	45	218	
26. **Sandstone, Berea,** coarse, quartzitic	15	233	
27. Shale and sandstone, brown, interlaminated	65	298	
Chemung Series, (95′)			
28. Sandstone, and shale, brown, interlaminated, several thin zones of marine fossils. **Lot 16;** contains **Camarotoechia** cf. **contracta** Hall, pelecypod sp., crinoid sp., fragments of trilobites. **Lot 17** at lower stratigraphic level; contains **Camarotoechia** cf. **contracta** Hall, pelecypod sp. **Lot 18** toward base; contains **Camarotoechia** cf. **contracta** Hall	95	393	
Portage Series (170′)			
29. Sandstone and shale, greenish-gray, much broken, no fossils	170	563	
Total	..	563	
30. Concealed. Here the great overthrust **St. Clair Fault** of East River Mountain intervenes with the strata concealed for a horizontal distance of 105 feet. Section is continued southeastward but formations are in **ascending order,** the dip being southeastward but not overturned:			
Beekmantown Limestone (950′)			
31. Limestone, gray, hard, dolomitic, with a little chert to ravine	240	240	
32. Limestone, gray, hard, dolomitic, cherty	235	475	
33. Limestone, gray, hard, dolomitic	275	750	
34. Limestone, gray, hard, dolomitic, to small ravine	120	870	
35. Limestone, gray, hard, dolomitic, to end of outcrop east of old chimney..	80	950	
Stones River (Chickamauga) Limestone (487′)			
36. Limestone, gray, hard, with marine fossils **Lot 19,** near base; contains **Isotelus** sp. and ramose bryozoa	100	1050	
37. Limestone fragments, with marine fossils; poorly exposed but visible on east side of New River. **Lot 20,** near base of this portion; contains **Maclurea** sp. and bryozoa sp. **Lot 21,** near top of this portion; contains **Rafinesquina** cf. **minnesotensis** Winchell, bryozoa sp., **Orthoceras** sp., ostracods sp. Estimated thickness	387	1437	
Total	..	1437	

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Moccasin Limestone ( )			
38. Limestone, red, shaly, not measured..... ..		....	

The following section was measured, or in part estimated, by Dr. Prouty and the writer, its locality and other essential details being noted in the explanatory text:

Narrows Section.

Giles County, Virginia; starting at elevation 2150′ B. on a low spur at the extreme northwestern end of Wolf Creek Mountain west of Mill Creek and traversing northwestward about one mile to Wolf Creek; thence northeastward down Wolf Creek about 1.8 miles to Narrows, and thence northward along New River and the Norfolk and Western Railway about 2,000 feet to a fault and ravine; Nos. 1-16 were determined by pacing and computation; Nos. 17-19 being largely concealed but almost on the strike, are estimated; Nos. 20-38 were measured by hand or closely estimated; dips southeastward; arrangement in descending stratigraphic order.

	Thickness Feet	Total Feet	Intervals Feet
Stones River (Chickamauga) Limestone (390′)			
1. Limestone, black, hard, compact, not measured (dip 20°)..... ..		....	
3. Concealed, with cherty soil and sink-holes..150		150	
3. Concealed by drift, probably **Stones River (Chickamauga)** 240		390	390
Beekmantown Limestone (3687′)			
(Nos. 30-39, inclusive, may be **Elbrook** of Cambrian age.)			
4. **Chert, Narrows** (type locality), gray, with marine fossils, bedded outcrops all covered (2095′ B.). **Lot 101;** contains poorly preserved bryozoa sp..... 35		425	
5. **Chert, Narrows** (continued), gray, with cauliflower weathering and marine fossils. **Lot 102;** contains ramose bryozoa and crinoid stems 118		543	
6. **Chert, Narrows** (continued), gray at top, black at base, with marine fossils (2090′ B.). **Lot 103;** contains many poorly preserved ramose bryozoa and **Hebertella** sp..... 80		623	
7. **Chert, Narrows** (continued), gray and black 20		643	253
8. Limestone, gray, pure 35		678	
9. Chert, black 20		698	
10. Dolomite, gray 158		856	
11. Chert, gray, weathered out in large blocks, with fragments of dolomite; contains **Cryptozoon** 350		1206	
11. Chert, gray, weathered out in large blocks, with marine fossils (1980′ B.). **Lot 104;** contains abundant **Ophileta complanata** Vanuxem 90		1296	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
13.	Chert, gray, blocky, with dolomite	388	1684	
14.	Concealed, partly, with gray chert containing marine fossils; also pieces of gray cherty breccia with quartz pebbles; also river-terrace boulders (1855′ B.). **Lot 105;** contains many poorly preserved bryozoa, smooth ostracods, and pygidia of **Dalmanites** (fossils all in a loose block which may be drift—see discussion)	162	1846	
15.	Mostly concealed, chert drift and debris	425	2271	
16.	Dolomite, gray, sandy and oolitic, to road along Wolf Creek (1605′ B.)	165	2436	
17.	Dolomite, yellow, sandy, thin-bedded, prismatic or rhombohedral weathering (small amount visible), and concealed, estimated	350	2786	
18.	Dolomite, yellow	10	2796	
19.	Concealed to dam across Wolf Creek, estimated	200	2996	
20.	Dolomite, with streaks of buff shale	60	3056	
21.	Here there appears to be a fault along which the strata are concealed by debris for a horizontal distance of 500 feet. The nature and amount of throw were not determined	..	....	
22.	Dolomite, gray	40	3096	
23.	Dolomite, black	2	3098	
24.	Dolomite, shaly	4	3102	
25.	Dolomite, gray	60	3162	
26.	Dolomite, buff, shaly	25	3187	
27.	Dolomite, dark, massive	10	3197	
28.	Dolomite and shale, buff	40	3237	
29.	Dolomite, with yellowish-buff, sandy shale	30	3267	2624
30.	Dolomite, dark-gray, with a little chert, and red inclusions	20	3287	
31.	Shale, yellowish-buff, with dolomite	10	3297	
32.	Dolomite, dark-gray, with bedded gray chert, to ravine	20	3317	
33.	Dolomite, gray, with bedded gray chert, to Narrows Branch Station	75	3392	
34.	Dolomite, gray, with bedded gray chert	20	3412	
35.	Dolomite and shale, yellowish-buff	15	3427	
36.	Dolomite, gray, sandy, with incrustations of magnesium sulphate	50	3477	
37.	Dolomite, yellowish-gray, somewhat shaly, rhombohedral weathering, cavernous	350	3827	
38.	Dolomite, gray, sandy, with red inclusions along bedding-planes	50	3877	
39.	Dolomite, grayish-yellow, mostly concealed, to ravine and fault-plane	200	4077	

In No. 14 of the above section Fossil Lot No. 105 consists of a somewhat weathered block of chert, containing many ostracods and bryozoa, as contrasted to the gastropod **Ophileta** that may commonly be expected in this portion of the Beek-

mantown. Dr. Prouty, in naming the fossils, states that this lot may be of Black River age and may therefore be drift. Such inference is given added weight by the presence of river-terrace boulders at the same level, indicating that this boulder of chert may not be of even local origin, although it may have slumped from a higher level on the same mountain.

It is quite possible that Nos. 30-39 of section may be of Cambrian age, since these members revealed no Beekmantown fossils and the general characteristics favor the lithology of the Elbrook Limestone. In the absence of more positive proof, however, Dr. Prouty suggests that this portion be provisionally included with the Beekmantown.

The following section, measured by the writer with the help of Dr. Prouty and Paul H. Price, affords an almost uninterrupted view of the major portions of the Silurian and Ordovician on the eastern side of New River at the southern end of the narrows. In the top of the Clinton Series the presence of a thick quartzite that is apparently the same as the Keefer Sandstone of the Potomac Valley of West Virginia and Maryland is indicated, and in the same series the Fossil Ore Horizon and Iron Sandstone of northeastern Pennsylvania are also recognizable. The White Medina Sandstone and Red Medina Series are also too plain for any doubt as to their proper designation. In the case of the two feet of sandstone assigned to the Gray Medina there may be differences of opinion but the fact that the color suddenly changes from red to gray indicates a marked variation from the purely red beds of the Red Medina, while at the bottom the streak of black chert particles is evidence of unconformity tending to separate the formation from the underlying Lower Maysville Group and the total absence of fossils is another and even stronger proof that this rock does not belong in the Lower Maysville, since the latter is nearly always abundantly fossiliferous as is the case in the narrows. With the above evidence and with the knowledge that the formation has the same lithology as the Gray Medina in northeastern West Virginia the correlation of this stratum appears to be justified.

In the Martinsburg Series a very complete view is afforded and the fossil identifications of Dr. Prouty makes pos-

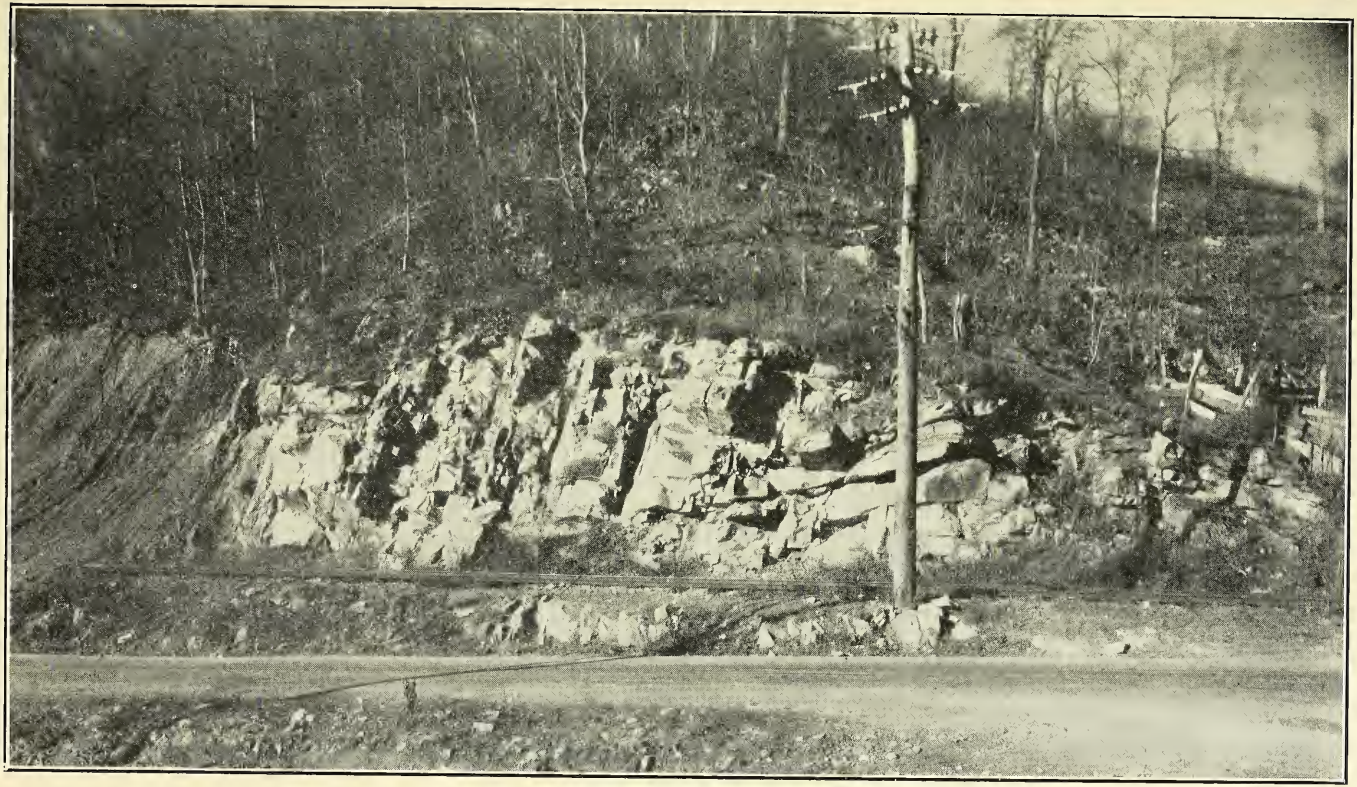


PLATE XI.—Stony Gap Sandstone (right) and Coney Shale (left) at Stony Gap, Mercer County, looking west into Stony Ridge. Beds overturned and now dipping southeastward 70°. Type locality of Stony Gap Sandstone. See Stony Gap Section. (Photo by Palmer & Fowler).

sible the division into the Lower Maysville, Eden, and Trenton Groups which he has indicated. In the Moccasin and Beekmantown Limestones no fossils were observed, and in the Stones River no collections were made:

Rich Creek Section.

Giles County, Virginia; on east side of New River starting in public road about one mile north of Narrows and traversing northward with the same through Nos. 1-30 of section to the top of the Moccasin Limestone and there offsetting to Virginian Railway grade for a measurement of the Moccasin, Stones River, and Beekmantown Limestones (Nos. 31-44), and stopping about one mile south of Rich Creek; length of traverse about 9,000 feet; dip, southeast; arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
1. Concealed by terrace clay (1585′ B.)	..	...	
Clinton Series (445′)			
2. **Sandstone, Keefer,** white, hard, massive, partly concealed but appears to be separated by shale into two ledges	100	100	100
3. Concealed	75	175	
4. Shale, gray	20	195	
5. Shale, reddish-brown, with numerous thin beds of siliceous iron ore **(Fossil Ore Horizon),** with pits which may be fossil remains. **Lot 37;** contains **Liocalymene clintoni** Vanuxem, **Calymene** cf. **macropleura** Prouty, **Buthotrephis gracilis** var. **intermedia** Hall, **Chonetes** cf. **novascoticus** Hall, **Camarotoechia neglecta** Hall, **Calymene cresapensis** Prouty, **Zygobolbina** cf. **emaciata**	60	225	
6. Shale, greenish-gray, with streaks of sandstone and marine fossils. **Lot 36,** near top; contains **Tentaculites minutus** Hall, **Camarotoechia neglecta** Hall, **Liocalymene clintoni** Vanuxem, **Coelospira hemispherica** Hall, **Dalmanella** sp., crinoid stems, **Calymene** sp., **Zygobolbina emaciata** U. & B., **Zygobolba** cf. **decora** Billings. **Lot 35,** slightly lower in strata; contains **Chonetes novascoticus** Hall, **Coelospira hemispherica** Hall, **Zygobolba** sp., crinoid stems. **Lot 34,** slightly lower than No. 35; contains **Tentaculites minutus** Hall, crinoid stem, **Coelospira planoconvexa** Hall var., **Coelspira hemispherica** Hall, **Calymene clintoni** Vanuxem. **Lot 33,** at base; collection lost	120	375	
7. Concealed	50	425	
8. **Sandstone, Iron Sandstone,** slightly ferruginous	20	445	345

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
White Medina Sandstone (120′)				
9.	**Sandstone, White Medina,** white, massive, coarse and hard, with quartz pebbles on extreme base; contains **Scolithus**	120	565	
Red Medina Series (390′)				
10.	Sandstone, red, with red shale	390	955	
Gray Medina Series (2′)				
11.	**Sandstone, Gray Medina,** with streaks of black chert at base	2	957	512
Martinsburg Series—Lower Maysville Group (362′)				
12.	Sandstone, gray, friable, **Lingula Zone,** with many marine fossils. **Lot 22;** contains **Orthorhynchula linneyi** James, **Modiolopsis** sp., **Byssonychia radiata** Hall, **Lingula nicklesi** Bassler, **Clidophorus** sp., **Zygospira** close to **erratica** Hall	56	1013	
13.	Sandstone, grayish-brown, friable, with many marine fossils, **Orthorhynchula Zone. Lot 23;** contains **Orthorhynchula linneyi** James, **Modiolopsis modiolaris** Conrad, **Modiolopsis** sp., **Byssonychia radiata** Hall.	55	1068	
14.	Shale, greenish-gray, with rhombohedral weathering and thin beds of limestone, numerous marine fossils, **Orthorhynchula Zone** (continued). **Lot 24;** contains **Rafinesquina alternata** Emmons, cf. **Orthorhynchula linneyi** James, **Calymene callicephala** Green, **Lingula** cf. **nicklesi** Bassler, **Callopora sigillarioides** Nicholson	133	1201	
15.	Concealed, with shale	118	1319	
Martinsburg Series—Eden Group (455′)				
16.	Limestone and shale, interbedded with numerous marine fossils. **Lot 25;** contains **Rafinesquina alternata** Emmons, **Zygospira** sp., **Isotelus** sp.	6	1325	
17.	Concealed, with shale	225	1580	
18.	Limestone and sandy shale, interlaminated, with marine fossils. **Lot 26;** contains **Plectambonites sericeus** Sowerby, cf. **Isotelus gigas** Dekay, **Rafinesquina alternata** Conrad, **Zygospira recurvirostris** Hall, **Dalmanella** sp., **Cryptolithus tesselatus** Green, ostracod sp.	35	1615	
19.	Limestone and sandy shale, interlaminated, with marine fossils. **Lot 27;** contains **Plectambonites sericeus** Sowerby, **Isotelus gigas** Dekay, **Rafinesquina** sp., **Plectambonites** sp., ramose bryozoa sp., **Zygospira** sp.	35	1650	
20.	Limestone and sandy shale, interlaminated, with marine fossils. **Lot 28;** contains **Calymene callicephala** Green, **Plectambonites sericeus** Sowerby, **Zygospira modesta** Hall, **Hormotoma** sp., **Zygospira** cf. **recurvirostris** Hall, **Strophomena** cf. **sinuata** James, **Rafinesquina** sp.	55	1705	

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
21. Limestone and sandy shale, interlaminated, with marine fossils	68	1773	
22. Shale, sandy, with marine fossils, **Lot 29; Diplograptus** cf. **vespertinus** Ruedemann, **Plectambonites sericeus** Sowerby	1	1774	
Martinsburg Series—Trenton Group (731′)			
23. Limestone, shaly, and shale, with marine fossils, to ravine. **Lot 30;** contains **Zygospira recurvirostris** Hall, **Plectambonites sericeus, Plectambonites** cf. **rugosus** Meek, **Zygospira** cf. **modesta** Hall	100	1874	
24. Limestone, flaggy, with marine fossils	115	1989	
25. Limestone, blue, hard	50	2039	
26. Limestone, blue, hard, with marine fossils, **Lot 31;** contains **Rafinesquina alternata** var., **Delmanella testudinaria** Dalman, **Isotelus gigas** Dekay	100	2139	
27. Limestone, blue, hard, with some shale and a few marine fossils, to private road. **Lot 32;** contains **Dalmanella testudinaria** Dalman, **Sinuites** cf. **cancellatus** Hall, **Dalmanella** sp.	190	2329	
28. Limestone, black, with shaly streaks	43	2372	
29. Shale, yellow, sandy, rhombohedral weathering	48	2420	
30. Limestone and shale, mixed, both being black and carbonaceous (1615′ B.)	85	2505	
(Thence offsetting to Virginian Railway grade):			
Moccasin Limestone (419′)			
31. Limestone, reddish, impure, partly concealed	206	2711	
32. Concealed, mostly, with some red limestone.	179	2890	
33. Limestone, reddish, hard (1545′ B.)	34	2924	
Stones River (Chickamagua) Limestone (618′)			
34. Limestone, gray, flaggy	60	2984	
35. Concealed	78	3062	
36. Limestone, dove-colored, hard, massive, with marine fossils, and with a little black chert at base	210	3272	
37. Concealed across ravine	25	3297	
38. Limestone, dark, with black chert and marine fossils	185	3482	
39. Limestone, dove-colored, pure, with veins of calcite	10	3492	
40. Limestone, dark, with much interbedded black chert	50	3542	
Beekmantown Limestone (910′)			
41. Concealed, partly, with ledges of dolomite; a little black chert near top	100	3642	
42. Dolomite, very hard, with gray chert and a little reworked conglomeratic material	470	4112	
43. Dolomite, gray, with gray chert and streaks of interbedded shale	340	4452	
44. **St. Clair Fault**	..	....	

Farther south along New River a good view of the lower portion of the Stones River and upper part of the Beekmantown Limestone is afforded in the following section, measured by Dr. Prouty and the writer in the vicinity of Ripplemead. In the Stones River (Chickamauga) there occurs a deposit of black marble such as frequently occurs in this formation in the highly faulted portions of Virginia and other southern States:

Ripplemead Section.

Giles County, Virginia; starting with New River Lime Company quarry on west side of New River just north of Ripplemead and traversing southward along Norfolk and Western Railway; dip, northwestward; approximate length of traverse 5,000 feet; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Stones River (Chickamauga) Limestone (235′)		
1. Limestone, black, with black chert and marine fossils, upper quarry rock .....45′ (New River Lime Company Quarry)		
2. Limestone, black, crystalline, mostly metamorphosed into black marble, basal quarry rock .....55 (New River Lime Company Quarry) 100		100
3. Concealed	45	145
4. Limestone, pure, with marine fossils, poorly exposed	90	235
Beekmantown Limestone (670′)		
5. Dolomite, gray, banded, with a little black chert..	10	335
6. Dolomite, gray, with a little gray chert, to apparent fault about one mile south of Ripplemead (1625′ B.) 570		905

In the following section, measured by Dr. Prouty and the writer on the eastern side of New River at Snidows Ferry, opposite Ripplemead and thence northward instead of southward, another exposure of the same beds is afforded. In the upper part of the Beekmantown there is a fault graben at which a section of the overlying Stones River has sunk down into the mass of the dolomite. The graben may be plainly seen on both sides of New River:

Snidows Ferry Section.

Giles County, Virginia; starting in bottom of shallow syncline a few hundred feet north of the east end of Snidows Ferry (now a bridge) and traversing northward and northwestward along eastern side of New River and mostly with Virginian Railroad grade to point where Potts Valley Division of Norfolk and Western Railwaay crosses the Virginian; dip, southeast; arrangement in descending stratigraphic order; approximate length of traverse, 7,800 feet.

	Thickness. Feet.	Total. Feet.
Stones River (Chickamauga) Limestone (305′)		
1. Limestone, black, crystalline, with black chert	155	155
2. Limestone, gray, with black chert and marine fossil fragments, to north edge of abandoned quarry	150	305
Beekmantown Limestone (590′)		
3. Dolomite, gray, banded	155	460
4. Following No. 3 in the line of traverse the surface formation for a horizontal distance of 180 feet along the railroad is a gray limestone carrying black chert and is apparently **Stones River (Chickamauga) Limestone** which may be accounted for only by block faulting down through the dolomite. The amount of dolomite forced down by the fault block, or graben, is approximately..	40	500
5. Dolomite, gray, quarry rock (Virginian Lime Corporation Quarry)	285	785
6. Dolomite, gray, measured vertically down from north end of quarry to Virginian Railway	65	850
7. Dolomite, sandy, and having quartz pebbles; has some spherical, banded weathering which indicates **Cryptozoon**	10	860
8. Dolomite, gray, to Norfolk and Western Railway bridge (1603′ L.)	35	895

MEASURED SECTIONS, PLYMOUTH DISTRICT, MERCER COUNTY.

Plymouth District occupies a portion of northeastern Mercer next to the Summers County line, its surface rocks being wholly included within the Mauch Chunk Series and ranging from the Bluestone Group down into the upper part of the Bluefield Group. In this district the strata are quite normal being only gently folded by the Abbs Valley Anticline which passes across it.

The following section measured by the writer, affords a good record of the Bluestone Group where it is preserved in the high monadnock of Bent Mountain, as well as a portion of the Hinton Group. In the Pride Shale, No. 9 of section,

the writer found a few small pelecypods but at a subsequent visit in the company of Dr. Girty nothing distinguishable was found according to a memorandum now on file:

Pride Section.

Plymouth District, Mercer County; starting at the triangulation point near the southern end of Bent Mountain 1.2 miles southeast of Pride and extending westward to the Bluefield-Hinton road near Ball School and thence southward with this highway to Laurel Creek 1.6 miles southward from Pride and 1.2 miles northeast of Athens; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluestone Group (558′)			
1. Concealed, with greenish-brown boulders and red, green, and sandy shale, from top of knob	108	108	
2. **Sandstone, Bent** (type locality), greenish-brown, flaggy, fine-grained (2910′ B.)	55	163	163
3. **Shale, Upper Bent** (type locality), red and green	55	218	
4. **Sandstone, Bratton,** green, fine-grained (2835′ B.)	20	238	75
5. **Shale, Bratton,** greenish-brown, sandy	30	268	
6. **Sandstone, Upper Belcher,** green, shaly	40	308	70
7. Shale, brown, sandy	175	483	
8. **Shale, Pride** (type locality), dark-green, or brown, sandy, weathering into pencil forms (2550′ B.); contains marine fossils, small pelecypods (see **Lot 204**)	40	523	
9. Concealed, continuation of **Pride Shale**	35	558	
Mauch Chunk Series—Princeton Conglomerate (25′)			
10. **Sandstone, Princeton,** massive, pebbly, cliff rock	25	583	275
Mauch Chunk Series—Hinton Group (235′)			
11. Concealed and reddish-brown shale, **Terry.**	15	598	
12. Sandstone, shaly, **Pluto Shale** horizon	30	628	
13. **Shale, Lower Pluto,** red	35	663	
14. **Sandstone, Falls Mills,** greenish-gray, massive at top, shaly at base, makes cliff (2350′ B.)	60	723	140
15. **Shale, Falls Mills,** red and variegated	40	763	
16. **Sandstone, Tallery,** shaly	10	773	
17. **Shale, Upper Tallery,** red	20	793	
18. **Sandstone, Low Gap,** shaly, to Laurel Creek (2255′ B.)	25	818	95

The following section, measured by Paul H. Price and the writer, indicates the surface rocks of the Laurel Creek Valley just east of Athens:

Athens Section.

Plymouth District, Mercer County; starting at the eastern edge of Athens near Concord State Normal School and traversing eastward down highway to Laurel Creek one mile east of Athens; gentle northwest dip; arrangement in descending stratigraphic order, measured with aneroid along approximate strike.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (305′)				
1.	Concealed	25	25	
2.	Shale, sandy	10	35	
3.	Concealed	5	40	
4.	Sandstone, coarse, somewhat shaly...15′			
5.	Shale, sandy... 5	**Falls Mills Sandstone**		
6.	Sandstone, coarse, streaked with shale, weathered to brown...20	(2515′ B.)... 40	80	80
7.	**Shale, Falls Mills,** yellow, sandy	5	85	
8.	**Sandstone, Tallery,** greenish-gray, medium coarse, streaked with shale (2470′ B.); lower portion quarried	40	125	45
9.	Concealed	10	135	
10.	**Shale, Lower Tallery,** red and variegated	25	160	
11.	**Sandstone, Low Gap,** very shaly	5	165	40
12.	Shale, yellowish-green, calcareous, with marine fossils; pelecypods (2405′ B.).....25′	**Low Gap Shale** 40	205	
13.	Shale, sandy.....15′			
14.	**Sandstone, Avis,** green, fine-grained, makes cliff	20	225	
15.	**Shale, Upper Avis,** green, fissile, with marine fossils, pelecypods	10	235	
16.	**Limestone, Avis,** steel-gray, shaly at middle with numerous marine fossils; brachiopods (**Orthotetes, Productus,** etc.), bryozoa, pelecypods (2310′ B.)	50	285	120
17.	Concealed to Laurel Creek (2290′ B.)	20	305	

MEASURED SECTIONS, MONROE COUNTY.

Monroe County contains in its northwestern half a considerable area in which the rocks of the Mississippian have been warped into folds of varying character, some being so gentle that they may be followed with difficulty while others are bolder with occasional dips of ten or fifteen degrees. In

the southwestern half of the county the folding becomes violent, there being overthrust faults and occasional overturns, although the wide overturn of the Mississippian and Devonian beds north of the St. Clair Fault, which is very evident across Mercer County, narrows rapidly in Monroe and northeast of Turkey Creek is almost wholly confined to the Devonian. The principal area of their change from overturned to normal beds is in the territory between Rock Camp and Turkey Creek where the force of the torque which always accompanies such phenomena is evident in the disturbed and crushed condition of the rocks.

The stratigraphy and structure of Monroe County have been previously known only in a general way, there being no report of any detailed character bearing upon it. Such being the case it is believed that the sections of the present Chapter will be of interest.

MEASURED SECTIONS, RED SULPHUR DISTRICT, MONROE COUNTY.

Red Sulphur District occupies the southwestern corner of Monroe County in the watershed of New River and adjoins Summers County, West Virginia, and Giles County, Virginia. Its surface rocks range from the Hinton Group of the Mauch Chunk Series of the Mississippian down nearly to the base of the Ordovician. In the northern portion the strata have been only gently disturbed by the Abbs Valley Anticline and corresponding Hurricane Ridge Syncline, but in the southern half they are distorted by overtrusts, overturns, and sharp dips.

The following section, measured by the writer, affords a good view of the Maccrady and Pocono Series in the region where they have been overturned but not much crushed or seriously distorted:

Brick Church Section.

Red Sulphur District, Monroe County; starting on Rich Creek 0.8 mile southeast of Brick Church and 2.7 miles southwest of Lindside and traversing southeastward about 1,000 feet up Rich Creek; strata overturned and now dipping southeastward 35° to 45°; arrangement in descending stratigraphic order; thicknesses estimated by pacing and vertical angles.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Greenbrier Series ( )			
1. **Limestone, Hillsdale (St. Louis** age as correlated in Kentucky), dark, hard, with black chert and marine fossils; not measured.. ..	....		
Maccrady Series (195')			
2. Limestone, yellowish, impure.....	20	20	
3. Shale, red, mostly concealed.....	100	120	
4. Limestone, yellow, siliceous.....	10	130	
5. Shale, red	20	150	
6. Sandstone, red, friable and shaly.....	20	170	
7. Limestone, yellow, siliceous.....	5	175	
8. Sandstone, greenish-yellow, shaly.....	10	185	
9. Shale, red and green.....	10	195	195
Pocono Series (276')			
10. Sandstone, green, shaly.....	8	203	
11. Shale, dark, bituminous.....	2	205	
12. Shale, sandy	10	215	
13. **Coal, Merrimac,** slaty **(Exposure No. 793 on Map IV)**.....	1	216	21
14. **Sandstone, Broad Ford,** partly gray and partly reddish-brown, shaly (1870' B.); contains plant fragments (fucoids?) and marine fossils, crinoids, brachiopods **(Chonetes, Productus,** etc.) (see **Lot 297**).	10	226	
15. Shale, sandy; contains marine fossils; crinoids	15	241	
16. Sandstone, shaly, weathering brown.....	20	261	
17. Sandstone and shale, interbedded, poorly exposed	100?	361	
18. **Sandstone, Broad Ford** (continued), green, with marine fossil fragments and a fucoid **(Taonurus cauda galli)**.....	10	371	
19. Concealed, partly, with greenish-brown sandstone and shale	50	421	
20. **Sandstone, Broad Ford** (continued), greenish-brown, partly concealed, with a fucoid **(Taonurus cauda galli)**; extends to ravine on east side of creek.....	50	471	255
Chemung Series ( )			
21. Sandstone, flaggy, and olive-green shale; contains marine fossils, crinoids..... ..	...		

The following section, measured by the writer, exhibits the Pocono Series, and in comparison with the Brick Church Section shows the rapid northeastward thickening that takes place in this group across Monroe County:

Lindside Section.

Red Sulphur District, Monroe County; starting on Dry Creek 0.4 mile southeast of Lindside and traversing southeastward about one-third mile up Dry Creek to Spruce Run; strata overturned and now dipping southeastward about 40°; arrangement in descending stratigraphic order; thicknesses estimated from pacing and vertical angles.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Maccrady Series ( )			
1. Shale, red, not measured	..	...	
Pocono Series (511′)			
2. Concealed, with sandstone boulders and shale, top portion might be Maccrady, estimated	250	250	
3. **Coal**, slaty 1′ 0″			
4. Fire clay shale 3 0			
5. **Coal**, soft, rotten, slaty 1 6			
(5′ 6″) **Merrimac ("Big Seam")** of Montgomery County, Virginia, (2025′ B.) Ernest Fleshman Prospect **No. 796 on Map IV).**	5½	255½	255½
6. Fire clay shale	4½	260	
7. **Sandstone, Lindside** (type locality), greenish or reddish-brown, ferruginous	50	310	
8. Shale, **coaly, Langhorne Coal** horizon, **"Little Seam"**, of Montgomery County, Virginia **(Exposure No. 802 on Map IV)**	1	311	55½
9. **Sandstone, Broad Ford**, reddish-brown, thick-bedded, partly concealed, to Spruce Run	200	511	
Chemung Series ( )			
10. Sandstone, green and flaggy, and green shales	..	...	

The following section, measured by the writer but later inspected in part by Dr. Girty and Paul H. Price in the course of fossil collections, gives very good details on part of the Mauch Chunk Series:

Red Sulphur Springs Section.

Red Sulphur District, Monroe County; starting at road fork 1.5 miles northward from Ballard and traversing northward along highway to Red Sulphur Springs; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (15′)			
1. **Sandstone, Stony Gap (Hinton** of Stevenson), massive, hard, coarse (2055′ B.)	15	15	15
Mauch Chunk Series—Bluefield Group (557′)			
2. Shale, green, sandy; contains marine fossils, pelecypods 10′			
3. Shale, yellow, sandy 15			
4. Shale, red, variegated 30			
Coney	55	70	

		Thickness. Feet.		Total. Feet.	Intervals. Feet.
5.	**Sandstone, Clayton,** reddish-brown, flaggy..	15		85	70
6.	Shale, red and variegated. 60′		**Clayton**		
7.	Shale, green, sandy.....10	70		155	
8.	**Sandstone, Graham,** shaly.....	4		159	
9.	**Limestone, Graham,** shaly, brecciated.....	1		160	
10.	**Shale, Upper Graham,** green.....	30		190	
11.	Shale, red	5		195	
12.	**Shale, Lower Graham,** green and variegated.	40		235	
13.	Shale, black	25		260	
14.	**Sandstone, Bertha,** shaly.....	10		270	
15.	**Shale, Upper Bertha,** red and variegated..	40		310	
16.	**Limestone, Bertha,** shaly (1745′ B.); contains marine fossils, brachiopods (especially **Orthotetes**), pelecypods, and crinoids (see **Lot 162**).....	15		325	240
17.	Sandstone, shaly	15		340	
18.	Shale, green, sandy.....10′				
19.	Shale, red.....25				
20.	Sandstone, shaly.....10				
21.	Shale, red 5		**Lower Bertha**		
22.	Limestone, shaly (1677′ B.), contains marine fossils, pelecypods 3	60	**Shale**	400	
23.	Shale, green..... 7				
24.	**Sandstone, Bradshaw,** shaly.....	20		420	
25.	Shale, red and variegated. 15′				
26.	Concealed and green shale 20		**Bradshaw**		
27.	Sandstone, shaly..... 2	75	**Shale**	495	
28.	Concealed, with red shale, to foot of hill.....38				
	Section continued by exposures in road 0.3 mile south of Red Sulphur Springs, there being a slight upward buckle at this point.				
29.	Sandstone, shaly	10		505	
30.	**Shale, Bradshaw** (continued), black; contains marine fossils, pelecypods.....	3		508	
			Red Sulphur Coal (type locality)		
31.	Slate, black, **coaly**.... 1′ 0″				
32.	Limestone 0 3	2	(1590′ B.)...	510	185
33.	Slate, black, **coaly**.... 1 0		**Exposure No. 775 on Map IV.**		
34.	**Shale, Bradshaw** (continued), sandy.....	15		525	
35.	**Sandstone, Indian Mills,** shaly.....	30		555	
36.	**Shale, Indian Mills,** sandy, with calcareous streaks	7		562	
37.	**Limestone, Raines Corner,** dark-gray, stylolitic at base, to Indian Creek at Red Sulphur Springs (1525′ B.); contains marine fossils at top, largely brachiopods, also gastropods, and bryozoa (see **Lot 248**)	10		572	62

MEASURED SECTIONS, SPRINGFIELD DISTRICT, MONROE COUNTY.

Springfield District lies northeast of Red Sulphur District and adjoins Summers County on the northwest and Giles County, Virginia, on the southeast. Its surface rocks range from the Hinton Group of the Mauch Chunk Series of the Mississippian down nearly to the base of the Ordovician. In its central and northwestern portions the rocks have been only moderately disturbed by the folds and warping but in the southeastern third there are highly distorted rocks, including overturned beds and an overthrust fault.

The following section, measured by the writer, shows a considerable portion of the Bluefield Group of the Mauch Chunk Series as it occurs in the valley of Indian Creek:

Wikel Section.

Springfield District, Monroe County; starting at top of ridge just northeast of Wikel and extending northeastward along highway to Indian Creek; measured with aneroid across approximately horizontal strata and arranged in descending order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (529′)				
1.	Shale, sandy, with sandstone .....25′	**Coney Shale.** 65	65	
2.	Shales, sandy and red....40			
3.	**Sandstone, Clayton,** soft.....	25	90	90
4.	**Shale, Clayton,** sandy and concealed.....	15	105	
5.	**Sandstone, Graham,** massive, coarse, soft..	25	130	40
6.	**Shale, Upper Graham,** sandy.....	15	145	
7.	Sandstone, shaly.....	10	155	
8.	Shale, greenish-gray.....25′	**Lower**		
9.	Shale, red.....20	**Graham** 45	200	
10.	**Sandstone Bertha,** green, shaly.....	20	220	90
11.	**Shale, Upper Bertha,** reddish-brown, sandy.	45	265	
12.	Sandstone	15	280	
13.	Shale, green, sandy.....14′			
14.	Shale, dark..... 1			
15.	Shale, reddish-brown.....15	**Lower Bertha**		
16.	Sandstone, green, shaly.. 5	**Shale** 50	330	
17.	Shale, sandy, partly concealed 15			
18.	**Sandstone, Bradshaw,** massive, coarse....	10	340	120
19.	Concealed, with sandy and red shales, **Bradshaw Shale** 115		455	
20.	**Sandstone, Indian Mills,** massive, coarse (1745′ B.)	10	465	125
21.	**Shale, Indian Mills,** reddish-brown.....	10	475	
22.	Limestone, very shaly.....	1	476	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
23.	**Shale, Indian Mills** (continued), reddish-brown; contains marine fossils, pelecypods (chiefly **Sphenotus**) (see **Lot 159A**, collected from Nos. 23 and 25 of section).	9	485	
24.	**Shale, Indian Mills** (continued), green, with plant fossils (0′ 6″) (see **Lot 159**).....	0½	485½	
25.	**Shale, Indian Mills** (continued), reddish-green; contains marine fossils, pelecypods, (see **Lot 159A**)	4½	490	
26.	Concealed, with variegated shale and sandstone, **Indian Mills Shale** (continued), estimated	25	515	
27.	**Limestone, Raines Corner** (type locality), gray, shaly, fucoidal, visible in bed of Indian Creek 0.5 mile northwest of Raines Corner; contains marine fossils, brachiopods, pelecypods, and gastropods (**Bellerophon**) (see **Lot 158**).....	5	520	55
28.	**Shale, Raines Corner** (type locality), sandy, with marine fossils, supplied from outcrop farther up Indian Creek.....	7	527	
29.	**Coal, Raines Corner** (type locality), visible at roadside 0.9 mile northwest of Raines Corner; thickness supplied from outcrop farther up Indian Creek (1′ 8″) (**Exposures Nos. 788 and 789 on Map IV**).....	2	529	

MEASURED SECTIONS, WOLF CREEK DISTRICT, MONROE COUNTY.

Wolf Creek District occupies the northwestern corner of Monroe County, next to Summers and Greenbrier. Its surface rocks range from the Hinton Group of the Mauch Chunk Series down into the lower portion of the Greenbrier Series of the Mississippian, its strata being considerably though not violently folded.

The following section, measured by the writer, shows the occurrence of the lower Mauch Chunk and a considerable portion of the Greenbrier Series on the western face of the Swoopes Knob plateau, but in Nos. 16-21, inclusive, the structure is dipping northwestward at a considerable rate and these thicknesses are therefore somewhat excessive:

Elmhurst Section.

Wolf Creek District, Monroe County; starting on high point 0.7 mile northwest of Knobs and extending northwestward to Wolf Creek at Big Cove School 0.5 mile north of Elmhurst; gentle southeast dip except in lower 210 feet where the structure dips rapidly northwestward; measured with aneroid and arranged in descending stratigraphic order, without corrections for dip.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (330′)				
1.	**Sandstone, Droop,** all eroded except a few boulders, thickness supplied from outcrop farther east	40	40	40
2.	**Shale, Talcott,** supplied; see No. 2 of Bickett Knob Section	15	55	
3.	**Shale, Ada,** supplied; see No. 3 of Bickett Knob Section	50	105	
4.	**Limestone, Reynolds** (type locality), shaly, with numerous marine fossils and also plant fossils, visible in road at edge of plateau; **Lot 180**; see No. 4 of Bickett Knob Section and Chapter XVIII for list	15	120	
5.	Shale, green, sandy and limy ..... 10′	**Bickett**	15	135	
6.	Shale, red 5				
7.	**Limestone, Glenray (Menard** age?), shaly (2860′ B.); contains marine fossils, brachiopods and some bryozoa (including **Archimedes**) (see **Lot 215**)	95	230	190
8.	Shale, **Lillydale ("Pencil Cave") (Menard** age), green at top, black at base, fissile (2760′ B.)	100	330	
Greenbrier Limestone (1065′)				
9.	**Limestone, Alderson,** black, shaly	10	340	
10.	**Limestone, Alderson,** shaly, with marine fossils, gastropods, pelecypods, brachiopods, and crinoids	5	345	
11.	Unrecorded, mostly **Alderson Limestone**	150	495	265
12.	**Limestone, Union,** gray, massive, pure (2375′ B.)	200	695	
13.	**Limestone, Pickaway,** massive, sandy, and stylolitic	80	775	
14.	**Limestone, Pickaway** (continued), gray, pure	70	845	
15.	Concealed	40	885	
16.	**Limestone, Pickaway** (continued), massive, sandy	140	1025	
17.	**Limestone, Pickaway** (continued), gray, much weathered, stylolitic	85	1110	
18.	Concealed, with limestone	70	1180	
19.	**Limestone, Taggard,** gray oolitic (1885′ B.)	5	1185	690
20.	**Shale, Lower Taggard,** red, sandy	5	1190	
21.	**Limestone, Patton,** gray, massive, to road fork at Big Cove School (1675′ B.)	205	1395	

For a section measured near Alderson and entitled the **Alderson Section**, reference should be made to Talcott District, Summers County, which is the actual ground location of the section; and another starting on the Swoopes Knobs plateau and Bickett Knob, and called the **Bickett Knob Section**, will be found under Union District, Monroe County, in which it is partly located.

MEASURED SECTIONS, UNION DISTRICT, MONROE COUNTY.

Union District occupies the central portion of Monroe County, its surface rocks ranging from the Bluefield Group of the Mauch Chunk Series of the Mississippian down to the top of the Devonian. In the principal part of this district the structure is considerably warped by anticlines and synclines but along the southeastern edge, in the vicinity of Little Mountain, the rocks are overturned by the pressure from the St. Clair Fault farther south. Opportunities for measuring good sections of long length are not readily afforded, since all the central portion consists of an old peneplain of low topographic relief and the western edge along the high eastern slope of the Swoopes Knobs plateau is so much arched by the Sinks Grove Anticline that observations made along the mountain roads northwest of Union and northwest of Salt Sulphur Springs could not be connected into continuous sections, although some of the individual exposures are good. The stratigraphy of the district, however, is well displayed in the following section, which actually crosses a corner of Union District, although partly located in Wolf Creek and Second Creek Districts:

Bickett Knob Section.

Wolf Creek, Union, and Second Creek Districts, Monroe County; starting at top of low knob which rises slightly from the general plateau 0.3 mile northwest of Knobs Post-Office and thence following the highway northwestward 0.4 mile to the edge of the plateau, including Nos. 1-4 of section, across rising strata; thence shifting to top of Bickett Knob as indicated below, and continuing northward to Nickells Mill; Nos. 5-39 measured with aneroid across approximately horizontal strata; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (410')			
1. **Sandstone, Droop,** white, massive, coarse, soft, weathering to white sand, 25 feet visible locally but being 40 feet at south end of Swoopes Knobs where it has not been eroded	40	40	40
2. **Shale, Talcott,** greenish-gray; contains marine fossils, largely brachiopods and bryozoa (see **Lot 182**)	15	55	
3. **Shale, Ada,** green, fissile, calcareous; contains numerous marine fossils, largely brachiopods and bryozoa (see **Lot 181**)	50	105	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
4.	**Limestone, Reynolds** (type locality), shaly; contains numerous marine fossils, chiefly brachiopods (especially **Orthotetes**) (see **Lot 180**—type locality); also contains plant fossils. Best exposed in road 0.6 mile northwest of Knobs P. O. This limestone is also partly exposed in extreme top of Bickett Knob and contains marine fossils, brachiopods and bryozoa (see **Lot 168**)	15	120	
	Section continued with exposures on north slope of Bickett Knob:			
5.	**Shale, Bickett** (type locality), red and sandy	30	150	
6.	**Sandstone, Webster Springs,** green, flaggy.	5	155	115
7.	**Limestone, Glenray,** shaly (3155′ B.); contains marine fossils, chiefly brachiopods with some bryozoa (including **Archimedes**) and crinoids (see **Lot 169**)	125	280	
8.	**Shale, Lillydale ("Pencil Cave"),** fissile, green at top but turning black at base (3025′ B.)	130	410	255
Greenbrier Series (1040′)				
9.	**Limestone, Alderson,** yellow, shaly, (2935′ B.); contains marine fossils, brachiopods, bryozoa (especially fenestelloids) and crinoid stems (see **Lot 170**).	90	500	
10.	**Limestone, Alderson** (continued), yellow, hard, sandy (2895′ B.); contains marine fossils, crinoids, bryozoa (including **Archimedes**), horn corals, and brachiopods (see **Lot 171**)	40	540	
11.	**Limestone, Union (Gasper** age), hard, blue, granular, with streaks of oolite (2870′ B.); contains abundant marine fossils, blastoids (**Pentremites**), crinoids, and bryozoa (including **Archimedes**) and horn corals (see **Lot 172**)	25	565	
12.	Shale, calcareous, with red shale.....	5	570	
13.	**Limestone, Union** (continued), (**Gasper** and **Fredonia** age), gray, hard, pure (2740′ B.); contains abundant marine fossils, blastoids (**Pentremites**), crinoids, brachiopods, and bryozoa (see **Lot 173**).....	125	695	
14.	**Limestone, Pickaway,** massive, very sandy.	35	730	
15.	**Limestone, Pickaway** (continued), black, hard, stylolitic, weathering gray.....	75	805	
16.	**Limestone, Pickaway** (continued), massive, sandy	60	865	
17.	**Limestone, Pickaway** (continued), gray, weathering yellow, quite sandy and impure (2505′ B.); contains marine fossils, bryozoa, crinoids, horn corals, and many large brachiopods (see **Lot 174**).....	65	930	
18.	**Shale, Upper Taggard,** red.....	15	945	
19.	**Limestone, Taggard,** grayish-white, oolitic			

PLATE XII.—Pinnacle Rock on northwest limb of Abbs Valley Anticline, one mile southeast of Simmons, Mercer County, looking northeastward. This is the Stony Gap Sandstone standing on edge with its top toward the camera. Slope in foreground is Hinton Group. (Photo by Palmer & Fowler).

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
	(2480′ B.); contains marine fossils, fragments of crinoids and bryozoa (see **Lot 175**)	10	955	545
20.	**Shale, Lower Taggard,** red, sandy	5	960	
21.	**Limestone, Patton,** shaly, impure, to low gap 1.5 miles southeast of Sinks Grove. Section continued by starting with base of same horizon one-third mile farther east:	85	1045	
22.	**Limestone, Patton** (continued), blue, hard, (2400′ B.); contains marine fossils, brachiopods, crinoids, and horn corals (see **Lot 176**—type collection)	55	1100	
23.	Concealed, with sandy shale	55	1155	
24.	**Limestone, Patton** (continued), blue, hard, very pure (2265′ B.); contains marine fossils, crinoids, blastoids (**Pentremites**), horn corals, and bryozoa (see **Lot 177**—type collection)	80	1235	
25.	**Limestone, Sinks Grove,** yellow, impure, with a little black chert (2220′ B.); contains marine fossils, bryozoa, brachiopods, and crinoids and horn corals (see **Lot 178**—type locality)	45	1280	
26.	**Limestone, Sinks Grove** (continued), blue, hard, with abundant black chert; contains marine fossils in chert and matrix, brachiopods, crinoids, bryozoa, and horn corals (see **Lot 179**—type locality) (This ledge is exposed at Sinks Grove and thence northward 1½ miles along road to Spider Den School and thence eastward one-half mile to road fork. Its lower portion frequently weathers out leaving only a gray chert weathered from the black.)	85	1365	
27.	Chert, gray (weathered from black), **Sinks Grove Limestone** (continued)	10	1375	
28.	**Limestone, Sinks Grove** (continued), dark, with black chert	15	1390	
29.	**Limestone, Sinks Grove** (continued), dark, not much chert	10	1400	
30.	Shale, sandy, **Sinks Grove Limestone** (continued)	2	1402	447
31.	**Limestone, Hillsdale** (**St. Louis** age as correlated in Kentucky), dark, with black chert and marine fossils, brachiopods	18	1420	
32.	Shale, **Hillsdale Limestone** (continued), sandy	2	1422	
33.	**Limestone, Hillsdale** (continued), dark, with black chert and marine fossils, corals (**Lithostrotion**)	15	1437	
34.	**Limestone, Hillsdale** (continued), dark, sandy, with some black chert (2040′ B.); contains marine fossils, crinoids, brachiopods and bryozoa (see **Lot 153,** collected from Nos. 31, 33, and 34)	13	1450	48

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Maccrady Series (290′)				
35.	Concealed	15	1465	
36.	Limestone, yellow, shaly; no fossils found	5	1470	
37.	Shale, red, with streaks of sandstone toward base	270	1740	290
Poono Series (40′)				
38.	Sandstone, shaly, to road fork at Nickells Mill	11	1751	
39.	Unobserved to Second Creek	29	1780	

The ground covered by the above section is the best exposure of the Greenbrier Series to be found in the entire Appalachian region and may well be considered as its type locality, since it was originally named by Dr. I. C. White as typical of the Greenbrier Valley without any more particular designation, and since the series here is fully exposed in a convenient place where the strata are horizontal and contain an abundance of marine life. It is quite true that the Greenbrier is thicker in Mercer County and in one or two counties in southwest Virginia, but all these exposures are in overturned or disturbed beds, partly concealed or otherwise less satisfactory. It is also true that perfect exposures of the series may be found at various localities where many of the members are absent or almost wholly attenuated. Further comment on this subject will be found in Chapter VIII.

MEASURED SECTIONS, SECOND CREEK DISTRICT, MONROE COUNTY.

Second Creek District occupies the northern part of Monroe County in the drainage of Second Creek and Greenbrier River, its surface rocks ranging from the Bluefield Group of the Mauch Chunk Series of the Mississippian down into the Chemung Series of the Devonian. In the western hafe or more the structure is wavy with anticlines and synclines of only moderate folding, but in the eastern part lateral compression has been much more severe and the rocks are crumpled into sharp anticlines.

The following section is of principal interest in showing a northern phase of the Maccrady Series, but also records portions of the Greenbrier and Pocono, the latter being exposed in the locality of a considerable dip and therefore somewhat inaccurate as to thicknesses:

Spider Den School Section.

Second Creek District, Monroe County, and Irish Corner District, Greenbrier County; starting at top of plateau 0.3 mile north of Spider Den School and following road northward to bridge across Second Creek 0.2 mile south of Hokes Mill; dip westward 8 to 10 degrees; measured with aneroid along approximate strike and arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Greenbrier Series (65′)			
1. Concealed, with gray chert weathered from black..25′			
2. Limestone, blue, hard, with black chert.....10	**Hillsdale (St. Louis age as described in Kentucky).** 65	65	65
3. Shale, sandy 10			
4. Limestone, blue, hard, with black chert (2115′ B.)..20			
Maccrady Series (115′)			
5. Shale, sandy	15	80	
6. Shale, red	35	115	
7. Sandstone, shaly	35	150	
8. Shale, red and green, sandy (2000′ B.).....	30	180	
Pocono Series (320′)			
9. **Sandstone, Logan (Burgoon) (Big Injun Oil Sand),** shaly, (dip southwest 10°).....	40	220	155
10. Shale, greenish-gray, sandy, with a little sandstone, to level of **Harry Ellis No. 4 Core Test (6)** (1855′ B.).....	105	325	
11. Concealed	80	405	
12. Sandstone, gray, shaly.....	20	425	
13. Shale, sandy, and concealed.....	30	455	
14. **Sandstone, Broad Ford,** reddish-brown at base, shaly, to Second Creek (dip northwest 10°) (1680′ B.).....	45	500	

The following section, also, shows approximately the same rocks as the last, being in the edge of Greenbrier County where Second Creek has cut a deep valley:

Hokes Mill Section.

Irish Corner District, Greenbrier County; starting at road fork on plateau 0.6 mile northwest of Hokes Mill, and following highway southeastward down hill to Second Creek just north of Hokes Mill; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Greenbrier Series (140′)			
1. Soil, with gray chert, weathered from black, **Sinks Grove Limestone**.....	15	15	
2. **Limestone, Hillsdale (St. Louis age as described in Kentucky),** with black chert; contains marine fossils, brachiopods.....125		140	140

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Maccrady Series (175′)				
3.	Shale, red	5	145	
4.	Limestone, yellowish-gray, shaly	5	150	
5.	Shale, red, with sandy streaks	95	245	
6.	Sandstone, shaly	40	285	
7.	Shale, sandy and variegated, with red shale (1815′ B.)	30	315	
Pocono Series (145′)				
8.	Sandstone, shaly	30	345	
9.	Shale, green, sandy	25	370	
10.	**Coal blossom, Merrimac (?), (1760′ B.) (Exposure 798 on Map IV)**	..	370	230
11.	Shale, sandy	20	390	
12.	**Sandstone, Broad Ford,** massive, gray, with streaks of shale, to Second Creek (1670′ B.)	70	460	

The following section, measured by the writer, shows some of the lower members of the Greenbrier Series as they occur in the deep valley of Second Creek, a portion of the section being designated as the type locality of the Patton Limestone:

Patton Section.

Second Creek District, Monroe County; starting in plateau at private road one-half mile south of Patton and extending northeastward to Second Creek one-third mile east of Patton; gentle southeast dip; measured with aneroid along approximate strike and arranged in descending stratigraphic order.

			Thickness. Feet.	Total. Feet.
Greenbrier Series (410′)				
1.	Limestone, gray.....20′			
2.	Limestone, sandy, flaggy, and shaly.....25			
3.	Limestone, gray and pure.60			
4.	Limestone, with black chert 5	**Patton Limestone** (type locality)	210	210
5.	Limestone, gray, pure....45			
6.	Limestone, with gray chert 15			
7.	Limestone, gray, pure, cavernous, with marine fossils, crinoids and brachiopods (1950′ B.)..40			
8.	Limestone, with black chert .....45′	**Sinks Grove Limestone**	115	325
9.	Limestone, dark, cherty, makes cliff.....55			
10.	Shale, sandy, laminated (1835′ B.) 15			

		Thickness. Feet.	Total. Feet.
11. Limestone, with black chert, and with marine fossils, bryozoa .....45'	Hillsdale Limestone (St. Louis of Butts in Kentucky and Tennessee)	85	410
12. Concealed, with limestone 20			
13. Limestone, dark, with marine fossils, horn corals and brachiopods, to creek (1750' B.).....20			

The following section measured by the writer, shows the nature of the Hillsdale Limestone in northeastern Monroe, being the same as that correlated with the St. Louis Limestone by Butts in the reports of the Kentucky Geological Survey on the Mississippian of Western and Eastern Kentucky:

Maple Grove School Section.

Second Creek District, Monroe County; starting near Greenbrier County line, in cross road between Second and Carpenter Creeks, 0.3 mile east of Maple Grove School, and traversing eastward to base of Greenbrier Series; dip, northwest; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Greenbrier Series (115')		
1. **Limestone, Sinks Grove,** dark, with black chert which weathers to gray and which contains marine fossils, bryozoa and crinoids..... ..	....	....
2. **Limestone, Hillsdale,** black (**St. Louis** age as described in Kentucky), hard, with black, interstratified chert and marine fossils, brachiopods (**Productus aff. semistriatus**) and horn corals....	20	20
3. Shale, dark, calcareous and sandy.....	15	35
4. **Limestone, Hillsdale** (continued), black, with a little black chert; contains marine fossils, brachiopods and corals	10	45
5. **Limestone, Hillsdale** (continued), gray, hard....	10	55
6. **Limestone, Hillsdale** (continued), dark, with black chert, shaly and poorly exposed.....	30	85
7. Concealed, with black chert.....	20	105
8. **Limestone, Hillsdale** (continued), dark, with black chert; contains marine fossils, bryozoa, brachiopods (**Spirifer**), and crinoids.....	10	115
Maccrady Series (10')		
9. Limestone, gray, shaly.....	10	125
10. Shale, red, sandy		...

MEASURED SECTIONS, SWEET SPRINGS DISTRICT, MONROE COUNTY.

Sweet Springs District occupies the southeastern corner of Monroe County, next to Craig and Alleghany Counties, Virginia. Its surface rocks range from the Greenbrier Series

of the Mississippian down nearly, if not quite, to the base of the Ordovician. Its rock structure is very much disturbed and broken, there being sharp anticlines, overturns, and overthrust faults, so that positions for measured sections must be selected with great care.

The following section, measured by the writer, is located in a region where Second Creek cuts a succession of gaps across nearly vertical strata, its alignment being almost at right angles to the line of dip and making almost ideal conditions for stratigraphic study wherever the rocks are not concealed. Fossil identifications were made by Dr. Prouty from collections of the writer:

Gap Mills Section.

Sweet Springs District, Monroe County; on Second Creek, starting at base of Greenbrier Limestone in road 0.3 mile west of Red Mill and traversing approximately 8,500 feet southeastward to St. Clair Fault at Gap Mills; strata overturned and now dipping southeastward; arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Maccrady Series (418′)			
1. Shale, red, estimated	200	200	
2. Shale, purple and variegated, sandy, with a little shaly sandstone	218	418	
Pocono Series (868′)			
3. **Sandstone, Logan (Burgoon) (Big Injun Oil Sand),** gray, shaly	238	656	656
4. Concealed, with sandstone and shale	250	906	
5. **Sandstone, Broad Ford,** gray, partly massive and partly shaly	160	1066	410
6. Shale, sandy, with a little sandstone	220	1286	
Chemung Series (1537′)			
7. **Sandstone, Hendricks,** reddish-brown, flaggy and shaly, with streaks of conglomerate, and numerous marine fossils. **Lot 137;** contains **Camarotoechia eximia** Hall & Clarke, cf. **Grammysia subarcuata** Hall, cf. **Cypricardinia elegans**	25	1311	245
8. Concealed across valley of Second Creek	315	1626	
9. Sandstone, brown, partly massive and partly shaly, with marine fossils. **Lot 131;** contains cf. **Douvillina cayuta** Hall	200	1826	515
10. Shale, olive-brown, with shaly sandstones and marine fossils	677	2503	
11. Sandstone, flaggy, with marine fossils	110	2613	787
12. Shale and flaggy sandstone, with marine fossils, **Spirifer**	210	2823	
Portage Series (2450′)			
13. Sandstone, green, flaggy; and shale, sandy; partly concealed	2450	5273	

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Hamilton Series (635′)			
14. Shale, green, somewhat aluminous, partly concealed	635	5908	3295
Oriskany Sandstone (140′)			
15. Sandstone, brown, massive, with chert, partly concealed	140	6048	
Helderberg Limestone? (72′)			
16. Concealed	72	6120	
Clinton Series (358′)			
17. **Sandstone, Keefer,** white, quartzitic	55	6175	
18. Concealed, with red soil	138	6313	
19. Shale, yellow, sandy, with marine fossils, trilobites, etc	95	6408	
20. **Sandstone, Iron Sandstone,** red, ferruginous	70	6478	570
White Medina Sandstone (110′)			
21. Sandstone, white, quartzitic and pebbly, with **Arthrophycus** on base of one bedding-plane	110	6588	
Red Medina Series (330′)			
22. Sandstone, red; and shale, red; in streaks, to St. Clair Fault at Gap Mills	330	6918	

The above section reveals the greatest thickness of Maccrady found at any point in the three counties, its total of 418 feet being about one-half of its apparent maximum near its type locality in Smyth County, Virginia. It is poorly exposed, however, so that few details may be obtained. There is also recorded a thickness of 868 feet of Pocono Series, showing a continued northeastward thickening of this formation, a feature of note being the presence of the Logan (Burgoon) Sandstone, or Big Injun Oil Sand, which is not noted in sections of the same series farther southwest in Monroe and Mercer Counties. The two coals occasionally found in this group belong in the concealed interval, No. 4 of section, and may or may not be present, but in either case would probably be worthless. Exposures in the lower two-thirds of the Devonian are poor and identifications are accordingly subject to doubt, but in the Silurian the relationships are very plain.

The following section, obtained by the writer, is little more than a hasty reconnaissance with estimated thicknesses but it illustrates the fact that the Logan Sandstone does not regularly occur in the Pocono Series of this region. It also records the appearance of a conglomerate which becomes a conspicuous feature of the upper part of the Chemung Series in southeastern Monroe County. The contact between the

Pocono and Chemung is not apparent in the section but belongs somewhere in the 300 feet of sandy shale obtained in No. 6 of section:

Roxalia Section.

Sweet Springs District, Monroe County; starting at the Maccrady-Pocono contact on the Devil Creek road 0.9 mile northeast of Roxalia Springs and traversing southward along highway to the gap of Middle Mountain; dip, northwest; thicknesses estimated; arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Maccrady Series ( )		
1. Shale, deep red, not measured	..	...
Pocono and Chemung Series (545')		
2. Shale, sandy, slightly red	50	50
3. Sandstone, gray, massive, coarse	10	60
4. Shale, sandy	150	210
5. Sandstone, gray, massive, pebbly	15	225
6. Shale, sandy	300	525
7. **Sandstone, Lackawaxen,** massive, conglomeratic, with oblong quartz pebbles some of which are one inch in length	20	545
8. Shales and sandstone, with marine fossils, not measured	..	....

The following section, measured by the writer in the edge of Greenbrier County only a few miles north of the Monroe line, gives a much better view of the Pocono Series:

Caldwell Section.

White Sulphur District, Greenbrier County, West Virginia; starting in a synclinal flexure along the main line of the Chesapeake and Ohio Railway one-third mile southeast of Caldwell village and about 150 feet west of Caldwell (main line) Station, and traversing southeastward about one-half mile up Howard Creek, the exposures being partly along the C. & O. Ry. and partly along the paved highway (Midland Trail) north of the creek; dip, northwest 15° to 35°; arrangement in descending stratigraphic order; thicknesses estimated from pacing and vertical angles.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Maccrady Series (75')			
1. Shale, red, green, yellow and sandy, visible	75	75	
Pocono Series (420')			
2. Shale, dark, with coaly streaks, **Merrimac Coal, "Big Seam"** of Montgomery County, Virginia	5	80	80
3. Shale, yellow	15	95	
4. Shale, green, very sandy, almost a sandstone, **Lindside Sandstone** horizon	15	110	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
5.	Shale, dark, carbonaceous, **Langhorne Coal** horizon, "Little Seam" of Montgomery County, Virginia, streak	..	110	30
6.	Shale, yellow, concretionary	10	120	
7.	**Sandstone, Broad Ford,** green, weathering brawn, thick-bedded, micaceous, visible at south end of railroad cut and on both sides of creek and having fucoids **(Taonurus cauda galli)** at exposure north of creek	75	195	85
8.	Concealed and **(Sunbury ?)** shale, estimated	150	345	
9.	**Sandstone, Berea,** flaggy and shaly at top, greenish-brown and thick-bedded at base; visible on both sides of creek (Nos. 10-16, inclusive, are visible along Midland Trail.)	75	420	225
10.	Shale, sandy	75	495	
Chemung Series (425′)				
11.	Sandstone, **Hendricks,** greenish, flaggy, with marine fossils (1755′ B.). **Locality 143;** contains **Cypricardinia** sp., **Rhipidomella** sp., the same as Lot 142, many very small smooth ostracods. **Bellerophon** sp. "Lots 142 and 143 appear to be the same sandstone and probably Hendricks"	50	545	125
12.	Concealed and shale, estimated	200	745	
13.	**Sandstone, Lackawaxen Conglomerate,** with abundant oblong and flattened quartz pebbles some of which are 2″ long	75	820	275
14.	Shale, green, and sandy	50	870	
15.	Sandstone, shaly, with several streaks of quartz conglomerate	50	920	100
16.	Shale, greenish, not measured	..	...	

In the above section both of the Pocono Coals which occur in Montgomery and other counties of Virginia and which are therein commercially mined are apparently represented, the geographic names assigned to them being the same as those employed in a report on **The Valley Coal Fields of Virginia** by M. R. Campbell, R. J. Holden, and others, as published by the Virginia Geological Survey in cooperation with the United States Geological Survey. It is of further interest that the upper portion of the series above the coals, including the Logan Sandstone, or Big Injun Oil Sand, is totally absent just as was found to be the case at Roxalia and many other southern localities. Farther down in the group the Broad Ford Sandstone is recorded, carrying the peculiar and easily recognized fucoid **Taonurus caudi galli** which may be noted in beds of the same age in the New Providence Formation of central Kentucky, the Grainger of

northeastern Tennessee, the Price of Virginia, and the Pocono of southern West Virginia. Northeast of this locality not a single specimen has been found by the writer between Greenbrier County and the type locality of the Pocono in northeastern Pennsylvania.

In the Chemung Series the identification of the Hendricks Sandstone of Tucker County is confirmed by the fossil report of Dr. Prouty and farther down the great Lackawaxen Conglomerate which is conspicuous in all this region is found at its proper position in the series.

In the following section the upper 26 members were examined and marine collections made by Dr. Prouty and the writer, the collection at Lot 129 in the lower portion of the Beekmantown Limestone having been made later by the writer. The fossils were all studied and identified by Dr. Prouty:

Hanging Rock Section.

Sweet Springs District, Monroe County; on north slope of Peters Mountain starting at the road summit one mile east of Hanging Rock and descending with road to foot of mountain 3.1 miles southwest of Gap Mills and thence North 40° West toward Gap Mountain; dip, southeastward; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
White Medina Sandstone (60′)			
1. **Sandstone, White Medina**, white, hard, and coarse; makes escarpment of Peters Mountain, visible	60	60	
Red Medina Series (360′)			
2. Sandstones and shales, red, poorly exposed (3340′ B.)	360	420	420
Martinsburg Series—Lower Maysville and Eden Groups (1023′)			
3. Shale and sandstone, partly concealed, with marine fossils. **Lot 71**; contains **Orthorhynchula linneyi** James, **Lingula nicklesi** Bassler, **Modiolopsis modiolaris** Conrad, **Tetranota obsoleta** Ulrich, **Byssonychia** cf. **radiata** Hall, **Orthoceras** sp., **Modiolopsis** sp.	35	455	
4. Shale, yellow, partly concealed; contains marine fossils, **Orthorhynchula linneyi**, etc.	60	515	
5. Shale, yellow, and limestone, flaggy, not examined in detail	910	1425	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
6.	Limestone, shaly, with marine fossils. Lot 98; contains Rafinesquina altenata Emmons, Zygospira modesta Hall, Isotelus sp., cf. Plectambonites sericeus Sowerby, small ramose bryozoa sp.	18	1443	1023
	Martinsburg Series—Trenton Group (322')			
7.	Shale and limestone, with marine fossils. Lot 97; contains Prasopora simulatrix, Zygospira recurvirostris Hall, Liospira sp., graptolites sp., Hormotoma sp., Plectambonites cf. sericeus Sowerby, Isotelus sp.	10	1453	
8.	Limestone, shaly, with marine fossils. Lot 96; contains Rafinesquina alternata Emmons, Plectambonites sericeus Sowerby, Zygospira recurvirostris Hall, Pholidops close to cincinnaticus	12	1465	
9.	Limestone, shaly, with marine fossils. Lot 95; contains Zygospira recurvirostris Hall.	15	1480	
10.	Limestone, shaly, with marine fossils. Lot 94; contains Prasopora simulatrix Ulrich, Plectambonites sericeus Sowerby, Zygospira recurvirostris Hall, Isotelus cf. gigas Dekay	25	1505	
11.	Limestone, shaly, with marine fossils. Lot 93; contains Dalmanella testudinaria Dalman, ramose bryozoa sp., Plectambonites sericeus Sowerby, Isotelus sp.	20	1525	
12.	Limestone, shaly, with marine fossils. Lot 92; contains Plectambonites sericeus Sowerby, Zygospira recurvirostris Hall, Zygospira cf. modesta Hall, Isotelus sp., fragments	15	1540	
13.	Limestone, shaly, with streaks of shale and marine fossils. Lot 91; contains Zygospira recurvirostris Hall, Dalmanella testudinaria Dalman, Dalmanella cf. multisecta, Dalmanella sp., more electra than testudinaria, Plectambonites sericeus Sowerby, Diplograptus vespertinus Ruedemann, cf. Cryptolithus tessalatus Green, bryozoa sp.	45	1585	
14.	Shale, yellow; limestone, shaly; and shale, yellow; with marine fossils. Lot 90; contains Zygospira modesta Hall, Dalmanella testudinaria Dalman, Rafinesquina alternata Emmons, cf. Strophomena incurvata Shepard, Rafinesquina var. fracta Meeks, Plectambonites sericeus Sowerby, Prasopora simulatrix Ulrich, Rafinesquina cf. alternistriata Hall, Zygospira recurvirostris Hall	20	1650	
15.	Limestone, shaly; and shale, sandy; with marine fossils. Lot 89; contains Cyclora sp., cf. Ctenodonta levata Hall.	15	1620	
16.	Limestone, shaly, with marine fossils. Lot 88; contains Cyclora sp., gastropod sp.	5	1625	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
17.	Limestone, shale, and limestone, with marine fossils. Lot 87; contains Prasopora simulatrix Ulrich, Rafinesquina cf. alternata Emmons, Isotelus gigas Dekay, bryozoa sp., gastropod sp., like one in Lot 88.....	15	1640	
18.	Limestone and shale, with marine fossils. Lot 86; contains Praspora simulatrix Ulrich, Orthoceras sp., large gastropod sp.	8	1648	
19.	Limestone and shale, with marine fossils. Lot 85; contains Dalmanella multisecta Meek, Rafinesquina alternata Emmons, Dalmanella cf. testudinaria Dalman, Calymene sp., bryozoa sp.....	7	1655	
20.	Shale, yellow, with streaks of limestone, and with marine fossils. Lot 84; contains Rafinesquina alternata Emmons, Plectambonites sp., Calymene sp., Ceraurus sp., Pterygometopus sp.....	16	1671	
21.	Limestone, blue, shaly, with marine fossils. Lot 83; contains Sinuites cf. cancellatus, Spyroceras bilineatum Hall, Isotelus cf. gigas Dekay	4	1675	
22.	Limestone, blue, with streaks of shale and with marine fossils. Lot 82; contains Rafinesquina alternata Emmons, Prasopora simulatrix Ulrich, pelecypod sp....	20	1695	
23.	Limestone, blue, shaly, with marine fossils. Lot 81; contains Zygospira modesta Hall, Rafinesquina alternata Emmons, Dalmanella testudinaria Dalman, Isotelus gigas Dekay, Plectambonites sp.....	10	1705	
24.	Limestone, blue, shaly, with marine fossils. Lot 80; contains Rafinesquina cf. alternata Emmons, Plectambonites sp.....	5	1710	
25.	Limestone blue, shaly, with marine fossils. Lot 79; contains Ceraurus pleurexanthemus Green, Rafinesquina cf. alternata Emmons, Pterygometopus callicephalus Hall, Prasopora simulatrix Ulrich, Dalmanella sp.....	5	1715	
26.	Limestone, blue, shaly, with marine fossils. Lot 78; contains Rafinesquina alternata Emmons, Spyroceras bilineatum Hall, trilobite sp.....	5	1720	
27.	Shale, yellow, sandy, with marine fossils, Lot 77; contains Pterygometopus cf. callicephalus, Dalmanella testudinaria Dalman, Calymene sp.....	15	1735	
28.	Shale, yellow, sandy, with marine fossils. Lot 76; contains Zygospira modesta Hall, Dalmanella cf. multisecta Meek, Ceraurus pleurexanthemus Green, Calymene sp....	5	1740	

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
29. Shale, yellow, sandy, with marine fossils. **Lot 75;** contains **Ceraurus pleurexanthemus** Green, **Dalmanella multisecta** Meek, **Rafinesquina alternata** Emmons, crinoid stems	5	1745	
30. Shale yellow, sandy, with marine fossils. **Lot 74;** contains **Dalmanella multisecta** Meek, **Rafinesquina alternata** Emmons...	5	1750	
31. Shale, yellow, sandy, with marine fossils. **Lot 73;** contains **Dalmanella** cf. **multisecta** Meek, **Isotelus** sp.	5	1755	
32. Shale, yellow, sandy, with marine fossils. **Lot 72;** contains **Dalmanella testudinaria** Dalman, **Isotelus gigas** Dekay	5	1760	
33. Shale, black, fissile, calcareous	5	1765	322
Moccasin Limestone (396')			
34. Limestone, red, impure, not examined in detail, but apparently non-fossiliferous	396	2161	
Chickamauga Limestone (690')			
35. Limestone, gray or dove-colored in middle and upper portion, dark and cherty at base, carries marine fossils. **Lot 70,** collected across outcrop; contains poorly preserved **Rafinesquina** sp., pelecypods, and small gastropods	690	2851	
Beekmantown Limestone (2400')			
36. Dolomite, gray, with scoriaceous chert in abundance; also contains **Cryptozoon;** one large gastropod found. **Lot 69;** contains **Maclurites** sp.	160	3011	
37. Dolomite, gray, with much gray scoriaceous chert, with occasional marine fossils. **Lot 129,** in extreme base; contains **Ophileta** sp.	2240	5251	
38. Concealed in vicinity of St. Clair Fault	..	....	

Besides showing a part of the Silurian the above section details a very considerable portion of the Ordovician, there being a part of the Martinsburg Series which was not examined in detail and there being possibly a few hundred feet of Beekmantown Limestone cut off by the St. Clair Fault at the base. The fossil collections in the Martinsburg were principally made in the Trenton Group, since a very careful search of the Eden Group had already been made in the Rich Creek Section, as published on pages 209-211. Taken in conjunction it is believed that the two sections afford a very complete record of this series, the division of which into its classical groups by Dr. Prouty has accordingly been made possible.

MEASURED SECTIONS, SUMMERS COUNTY.

The surface geology of Summers County is principally composed of the Mauch Chunk Series of the Mississippian, there being a fringe of Pennsylvanian along the western edge and certain isolated ridges at the north that contain it, and there being some small areas along the eastern edge where the top of the Greenbrier Series is exposed in the valley of Greenbrier River. Throughout most of the county there are very deep valleys where the Mauch Chunk is magnificently displayed in the steep roads which ascend the adjacent mountains. The rock structure is almost horizontal, the dip of the strata being very gentle except along the eastern edge where more perceptible rock slopes are found.

The stratigraphy of **Jumping Branch District,** occupying the western corner of the county and containing most of the Pennsylvanian outcrops, has already been studied by C. E. Krebs and his assistant, D. D. Teets, Jr., their measured sections being published in the Report of the Survey on Raleigh County and the Western Portions of Mercer and Summers Counties, pages 85-90, inclusive, and pages 168-169. No additional sections for this district have been measured for the present Report.

MEASURED SECTIONS, GREEN SULPHUR DISTRICT, SUMMERS COUNTY.

Green Sulphur District occupies the northern end of Summers County next to Greenbrier, Fayette, and Raleigh, its surface strata ranging from the New River Group of the Pottsville Series of the Pennsylvanian down to the Bluefield Group of the Mauch Chunk Series of the Mississippian. In the following section the surface portion was measured by the writer, the subsurface portion being the record of the **James H. Gwinn No. 1 Well (11),** the record of which has been publish on pages 377-378 of the Raleigh County Report of the Survey and on pages 357-358 of the Fayette County Report Since the dates of those publications a very large amount of information has been gained concerning the Mississippian Rocks so that it is now possible to identify the principal formations in the record:

Green Sulphur Springs Section.

Green Sulphur District, Summers County; starting at the top of Big Swell Mountain 1 mile southeast of Mountain View School and thence extending northwestward to this school and thence northeastward to the mouth of Mill Creek 0.4 mile south of Green Sulphur Springs; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Pottsville Series—Pocahontas Group (120′)				
1.	Sandstones and shales from top of Big Swell Mountain, not examined but stratigraphic thickness estimated after making deduction for southeastward rise	100	100	
2.	**Sandstone, Keystone,** buff, massive, pebbly, makes top of ridge near Mountain View School (2860′ B.)	20	120	120
Mauch Chunk Series—Bluestone Group (435′)				
3.	Shale, red and variegated	50	170	
4.	**Sandstone, Bent,** buff, coarse, micaceous, cliff rock (2795′ B.)	15	185	65
5.	Shale, red	75	260	
6.	**Sandstone, Upper Belcher,** green	30	290	
7.	**Shale, Upper Belcher,** red	65	355	
8.	**Sandstone, Lower Belcher,** green, flaggy, much weathered, makes sharp ridge (2585′ B.)	40	395	210
9.	**Shale, Lower Belcher,** sandy (2550′ B.), with marine fossils, pelecypods	35	430	
10.	Shale, sandy, horizon of **Glady Fork Sandstone**	55	485	
11.	**Shale, Pipestem,** dark	35	520	
12.	Fire clay shale, streak, **Pipestem Coal** horizon (2460′ B.)	..	520	
13.	**Shale, Pride,** green	35	555	
Mauch Chunk Series—Princeton Conglomerate (20′)				
14.	**Sandstone, Princeton,** green, massive, with gray streaks, somewhat soft and weathered (2405′ B.)	20	575	180
Mauch Chunk Series—Hinton and Bluefield Group (1765′)				
15.	**Shale, Terry,** red and variegated	25	600	
16.	Sandstone, green, massive, with streaks of shale	15	615	
17.	**Shale, Pluto,** dark-green (2342′ B.); contains numerous marine fossils, pelecypods	23	638	
18.	**Limestone, Pluto,** yellowish-green, shaly	2	640	
19.	Shale, green 15′			
20.	Concealed, and red shale 30			
21.	Shale, green, with sandstone 20	**Lower Pluto Shale**	85	725
22.	Sandstone, green, somewhat massive 5			
23.	Shale, yellowish-green 15			
24.	**Sandstone, Falls Mills,** greenish-brown, somewhat massive (2245′ B.)	10	735	160

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
25.	**Shale, Falls Mill,** red	60	795	
26.	Fire clay shale, streak, **Fivemile Coal** horizon	..	795	
27.	**Sandstone, Tallery,** shaly (2170′ B.)	15	810	
28.	**Shale, Upper Tallery,** red	25	835	
29.	**Sandtone, Low Gap,** reddish-brown	5	840	
30.	Shale, yellow, sandy.....10′			
31.	Shale, red .....15 } **Low Gap**	40	880	
32.	Shale, green, sandy.....15			
33.	**Sandstone, Avis,** shaly	5	885	
34.	Shale, red	10	895	
35.	**Shale, Upper Avis,** yellow, calcareous (2060′ B.); contains marine fossils, pelecypods	25	920	
36.	**Limestone, Avis,** gray, shaly (2025′ B.); contains marine fossils, brachiopods, pelecypods, crinoids, and bryozoa	35	955	220
37.	**Shale, Lower Avis,** yellow, limy; contains marine fossils, pelecypods, and brachiopods (including **Orthotetes**)	10	965	
38.	**Shale, Payne Branch,** red	45	1010	
39.	**Sandstone, Hackett,** reddish at top, green and shaly at base (1920′ B.)	50	1060	105
40.	**Shale, Hackett,** red	95	1155	
41.	Shale, yellow, horizon of **Tophet Limestone.**	15	1170	
42.	**Shale, Upper Tophet,** red	15	1185	
43.	**Sandstone, Tophet,** reddish-brown, hard, flaggy, with streaks of red shale (1780′ B.)	15	1200	140
44.	Shale, red .....10′ } **Lower**			
45.	Shale, yellowish-green....10 } **Tophet**	45	1245	
46.	Shale, red 25			
47.	**Sandstone, Goodwyn,** reddish-brown, shaly, (1720′ B.)	15	1260	
48.	**Shale, Upper Goodwyn,** red	14	1274	
49.	Limestone, yellow, very shaly (1705′ B.)	1	1275	
50.	**Shale, Lower Goodwyn,** red	15	1290	
51.	**Sandstone, Upper Bellepoint,** very shaly, mixed with red shale	20	1310	110
52.	Shale, red, with a little sandstone .....15′			
53.	Shale, green, sandy (1650′ B.); contains marine fossils, small pelecypods ..... 5 } **Upper Bellepoint**	55	1365	
54.	Shale, red 35			
55.	**Sandstone, Middle Bellepoint,** shaly (1605′ B.)	10	1375	65
56.	**Shale, Middle Bellepoint,** red	53	1428	
57.	Shale, green, to well mouth (1545′ L.)	7	1435	
	Section continued by record of James H. Gwinn No. 1 Well (**No. 11 on Map VI**):			
58.	Gravel	20	1455	
59.	Red rock	215	1670	
60.	Slate, white	15	1685	
61.	Lime, white	10	1695	

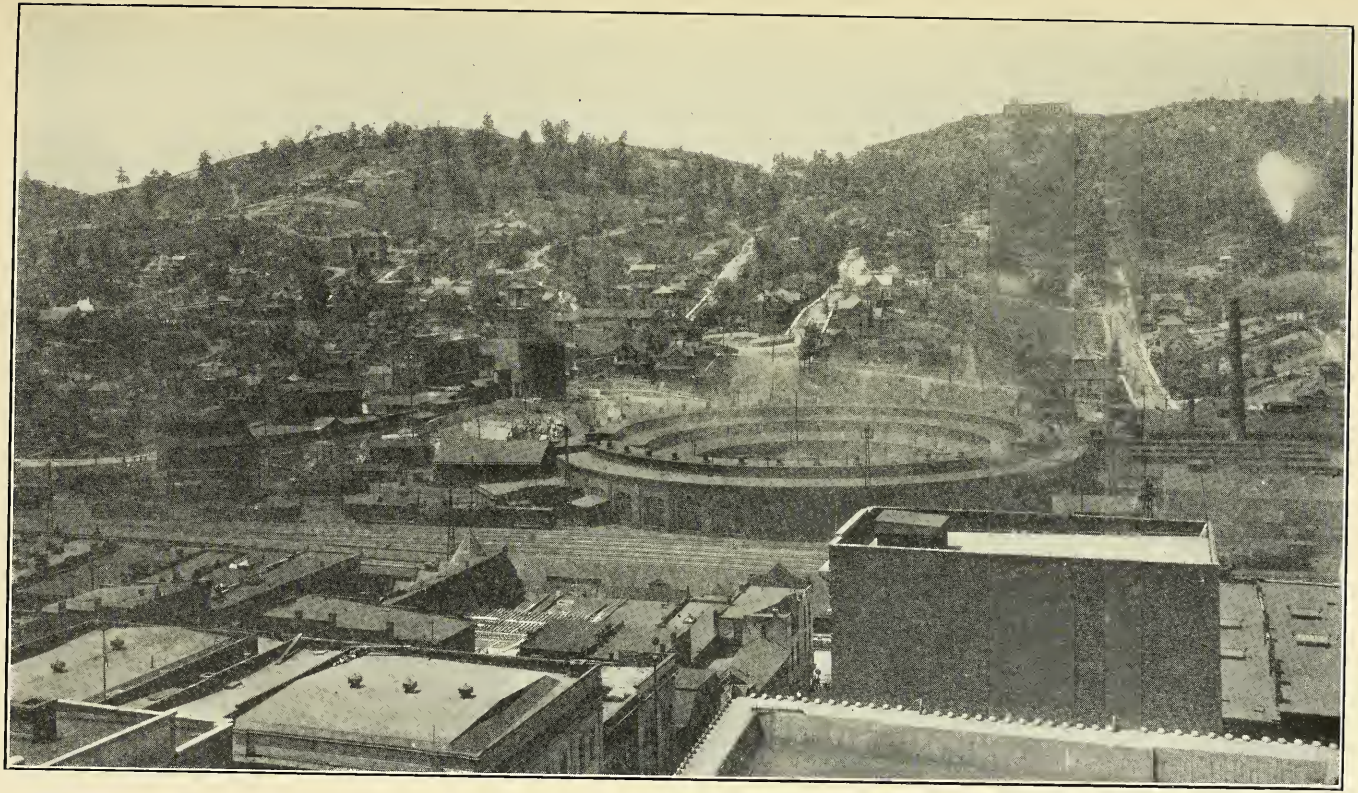


PLATE XIII.—Bluefield, looking north from roof of West Virginian Hotel. Background is Stony Ridge with its core of nearly vertical Stony Gap Sandstone plainly visible. Slope of ridge is Bluefield Group terminated by quarry in Greenbrier at left of N. & W. Railway roundhouse. Greenbrier extends under tracks and business blocks to locus of camera. (Photo. by Palmer & Fowler).

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
62.	Slate, white	20	1715	
63.	Red rock	20	1735	
64.	Slate	30	1765	
65.	Red rock	20	1785	
66.	Slate, white	15	1800	
67.	Red rock	25	1825	
68.	Lime, black	20	1845	
69.	Red rock	30	1875	
70.	Slate, white	20	1895	
71.	Red rock	40	1935	
72.	Lime, black, **Raines Corner**	10	1945	
73.	Red rock	45	1990	
74.	Slate, black, **Raines Corner Coal** horizon	15	2005	
75.	Sand, **Maxton (Droop Sandstone?)**	50	2055	680
76.	Slate, white, **Ada Shale**	100	2155	
77.	Lime, **Reynolds,** black	15	2170	
78.	Slate, white	3	2173	
79.	Lime, black	17	2190	
80.	Slate, white	10	2200	
81.	**Little Lime (Glenray Limestone),** black (**Menard** age)	65	2265	210
82.	Pencil Cave **(Lillydale Shale)** (**Menard** age)	75	2340	75
Greenbrier Series (695′)				
83.	**Big Lime (Greenbrier)**	695	3035	695
Maccrady Series (25′)				
84.	Slate, white	25	3060	25
Pocono Series (600′)				
85.	Sand, **Big Injun (Logan, Burgoon)**	75	3135	75
86.	Slate and shells	325	3460	
87.	Sand, **Weir,** gray	15	3475	
88.	Shells, hard lime **(gas show at 2100′)**	60	3535	400
89.	Slate	15	3550	
90.	Shells, hard lime	85	3635	
91.	Sand, **Berea,** white	25	3660	125
Chemung Series (775′)				
92.	Shells, flinty	65	3725	
93.	Slate, black	50	3775	
94.	Lime and shells, flint **(gas shows at 2365′ and 2760′)**	480	4255	
95.	Shale, black **(gas show at 2825′)**	5	4260	600
96.	Lime and flint	175	4435	

In the above section the thickness of the Mauch Chunk Series is 2,220 feet, as compared to 3,450 feet in the vicinity of Bluefield; and the Greenbrier is only 695 feet, as compared to 1,800 feet at Bluefield; and the Maccrady Series has almost completely disappeared, there being only 25 feet of white slate which is doubtfully assigned to it. The northward thinning in the Mauch Chunk appears to be fairly uniform throughout the series, exept that most of the formations above the Bent Sandstone have completely disappeared at

might be expected at such a stage of disconformity. In the driller's record of the Greenbrier no details are given by which its individual members can be noted. A strong stream of salt sulphur water now flows from the 14-inch casing which protrudes from the mouth of this well, there being numerous bubbles of a non-inflammable gas which is apparently hydrogen sulphide.

The following section, measured by the writer, affords a very good view of the Mauch Chunk Series, as well as the maximum of Pennsylvanian that is to be found in the northern portion of the county:

New Richmond Section.

Green Sulphur District, Summers County; starting on the top of Hump Mountain 1.8 miles southeast of Beurytown and traversing generally southwestward to New River at the mouth of Lick Creek just west of New Richmond; gentle northwest dip; measured with aneroid approximately on the strike and arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Pottsville Series—New River Group (55′)			
1. **Sandstone, Pineville,** massive, coarse, white, medium-hard, makes top of Hump Mountain (3245′ B.)	55	55	55
Pottsville Series—Pocahontas Group (490′)			
2. Concealed in slope and bench	65	120	
3. **Sandstone, Pierpont,** gray, massive, pebbly (3100′ B.)	80	200	
4. **Coal Prospect, No. 6 Pocahontas,** fallen shut, some coal on dump (3100′ B.) **(No. 745 on Map VI)**	..	200	145
5. Concealed, with sandstone, **Upper Pocahontas Sandstone**	130	330	
6. **Coal Prospect, No. 3 Pocahontas,** with blossom of coal visible (2970′ B.) **(No. 748 on Map VI)**	..	330	130
7. Concealed and shale	25	355	
8. **Sandstone, Lower Pocahontas,** gray, massive (2915′ B.)	30	385	
9. Shale, sandy, partly concealed	15	400	
10. **Sandstone, Keystone,** brown, coarse, micaceous; and sandy shale; in steep bluff	90	490	
11. **Coal blossom, Keystone,** (2800′ B.), **(No. 751 on Map VI)**	..	490	160
12. **Shale, North Fork,** greenish-gray, sandy, ferruginous	55	545	
Mauch Chunk Series—Bluestone Group (405′)			
13. **Sandstone, Bent,** green, shaly	25	570	
14. **Shale, Upper Bent,** greenish-yellow, sandy (2710′ B.)	10	580	90

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
15.	Shale, red	95	675	
16.	**Sandstone, Bratton,** shaly	5	680	
17.	Shale, red	55	735	
18.	**Sandstone, Upper Belcher,** shaly	5	740	
19.	**Shale, Upper Belcher,** red	65	805	
20.	**Sandstone, Lower Belcher,** green, shaly (2450′ B.)	35	840	260
21.	**Shale, Lower Belcher,** red	25	865	
22.	Shale, greenish-yellow	20	885	
23.	Shale, red	55	940	
24.	**Shale, Pride,** yellow (2340′ B.)	10	950	
Mauch Chunk Series—Princeton Conglomerate (60′)				
25.	**Sandstone, Princeton,** gray, massive, hard, coarse (2280′ B.)	60	1010	170
Mauch Chunk Series—Hinton Group (990′)				
26.	**Shale, Terry,** red	45	1055	
27.	Shale, red and variegated, partly concealed at base	120	1175	
28.	Shale, green	35	1210	
29.	**Shale, Upper Fivemile,** yellow and calcareous (2070′ B.), contains numerous marine fossils, pelecypods	10	1220	
30.	Shale, red and variegated	10	1230	
31.	**Limestone** boulders, **Tallery** (2060′ B.); contains marine fossils, brachiopods	..	1230	220
32.	**Shale, Upper Tallery,** variegated	40	1270	
33.	Shale, yellow	20	1290	
34.	Shale, variegated	25	1315	
35.	Concealed, with red shale	190	1505	
36.	**Sandstone, Hackett,** reddish-brown, shaly, makes cliff (1765′ B.)	20	1525	295
37.	Shale, red 20′			
38.	Sandstone, shaly 5	**Hackett Shale**	75	1600
39.	Shale, red 50			
40.	Sandstone, shaly	5	1605	
41.	**Shale, Upper Tophet,** red	15	1620	
42.	**Sandstone, Tophet,** reddish-brown, shaly, cliff rock (1640′ B.)	30	1650	125
43.	**Shale, Lower Tophet,** red, mixed with sandstone	50	1700	
44.	**Sandstone, Goodwyn,** shaly	5	1705	
45.	**Shale, Lower Goodwyn,** red	45	1750	
46.	**Sandstone, Upper Bellepoint,** brown, very shaly, cliff rock (1520′ B.)	20	1770	120
47.	Shale, red 38′			
48.	Limestone, greenish-yellow, hard, impure (1480′ B.) 2	**Upper Bellepoint Shale**	60	1830
49.	Shale, variegated 18			
50.	Limestone, greenish-yellow, shaly (1460′ B.) 2			
51.	**Sandstone, Middle Bellepoint,** shaly (1435′ B.)	25	1855	85
52.	Shale, sandy and variegated 13′	**Middle Bellepoint Shale**	15	1870
53.	Limestone, yellow, shaly (1420′ B.) 2			

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
54.	**Sandstone, Lower Bellepoint,** green, shaly..	13	1883	28
55.	Limestone, yellow, hard, siliceous ..... 1′			
56.	Shale, green, with plant fossils (1405′ B.)..... 1	**Lower Bellepoint Shale..** 42	1925	
57.	Slate, black, streak..... .			
58.	Shale, green, sandy, with plant fossils 40			
59.	**Sandstone, Stony Gap (Hinton** of Stevenson), greenish-gray, massive, hard, medium-grained, makes great cliff along Lick Creek at New Richmond (1290′ B.).	75	2000	117
Mauch Chunk Series—Bluefield Group (20′)				
60.	**Limestone, Coney,** greenish-yellow, shaly..	3	2003	
61.	**Shale, Coney,** red.....	7	2010	
62.	Concealed to New River at mouth of Lick Creek (1270′ B.)	10	2020	

In the above section the Avis Limestone should occur in the 190 feet of material covered by No. 35 of section, but it appears to be wholly concealed.

The following section, measured by the writer, gives another very good record of the three upper groups of the Mauch Chunk Series:

Ramp Section.

Green Sulphur District, Summers County; starting at the top of Chestnut Mountain 0.5 mile southwest of Rock Bottom School and following the highway generally northward to Laurel Creek 0.5 mile east of Ramp; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Pottsville Series—Pocahontas Group (35′)				
1.	**Sandstone, Keystone,** buff, coarse, micaceous, from top of knob (3100′ B.).....	35	35	35
Mauch Chunk Series—Bluestone Group (470′)				
2.	Shale, red	25	60	
3.	**Sandstone, Bent,** greenish-brown.....	15	75	
4.	Shale, red	85	160	
5.	**Sandstone, Upper Belcher,** green, shaly..	20	180	
6.	**Shale, Upper Belcher,** red, to road fork (2898′ B.)	57	237	
7.	Concealed	18	255	
8.	**Sandstone, Lower Belcher,** shaly (2835′ B.)	45	300	265
9.	Concealed, with red and sandy shale.....110		410	
10.	**Shale, Pride,** dark, sandy, visible.....	10	420	
11.	Concealed, with red and sandy shale (2630′ B.)	85	505	
Mauch Chunk Series—Princeton Conglomerate (25′)				
12.	**Sandstone, Princeton,** massive, pebbly (2605′ B.)	25	530	230

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (805′)				
13.	Concealed	70	600	
14.	**Shale, Pluto,** dark	50	650	
15.	Shale, red	75	725	
16.	**Shale, Falls Mills,** sandy	25	750	
17.	**Sandstone, Tallery,** shaly (2370′ B.)	15	765	235
18.	Shale, sandy	40′	**Upper**	
19.	Shale, red	5	**Tallery**	45	810	
20.	**Sandstone, Avis,** shaly	5	815	
21.	Shale, red	25	840	
22.	**Shale, Upper Avis,** yellow	30	870	
23.	**Limestone, Avis,** shaly (2240′ B.); contains marine fossils, brachiopods, gastropods, and crinoids	25	895	130
24.	**Shale, Lower Avis,** calcareous, with marine fossils	20	915	
25.	Shale, red	25	940	
26.	Concealed	45	985	
27.	**Sandstone, Hackett,** shaly, makes cliff on east side of branch (2075′ B.)	75	1060	165
28.	**Shale, Hackett,** red, partly concealed	205	1265	
29.	**Sandstone, Tophet,** shaly (1855′ B.)	15	1280	220
30.	Shale, red	10	1290	
31.	**Sandstone, Goodwyn,** shaly (1835′ B.)	10	1300	
32.	**Shale, Lower Goodwyn,** red	10	1310	
33.	**Sandstone, Upper Bellepoint,** shaly to Laurel Creek at road fork 0.5 mile east of Ramp (1800′ B.)	25	1335	55

MEASURED SECTIONS, GREENBRIER DISTRICT, SUMMERS COUNTY.

Greenbrier District occupies the central part of Summers County, its surface rocks ranging from the basal portion of the Pocahontas Group of the Pottsville Series of the Pennsylvanian down into the upper part of the Bluefield Group of the Mauch Chunk Series of the Mississippian; and the deep valleys of New and Greenbrier Rivers afford the exposures for a careful study of these strata.

The following section, measured by the writer, consists of observations at two different localities as detailed in the explanatory text, but the connection is perfect since the Princeton Conglomerate may be directly traced along the ridge of Keeney Mountain from the base of No. 12 to the top of No. 13 of section. Dr. David White made the collection of plant fossils at Lot 244, with the help of Paul H. Price and the writer, and his report and comment on the flora will be found in Chapter XVII:

Hinton Section.

Greenbrier District, Summers County; starting at the top of Stonelick Knob of Keeney Mountain 3 miles northeast of Hintotn; Nos. 1-12 measured southeastward to the top of the Princeton Conglomerate in the road 0.6 mile southeast of the knob; No. 13 starts at the top of the Princeton Conglomerate at the top of Keeney Mountain 1.5 miles southeast of Hinton and the traverse continues northwestward to New River 0.4 mile south of Hinton Station; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Pottsville Series—Pocahontas Group (90′)				
1.	Shale, sandy, with plant fossils, making top of Stonelick Knob	15	15	
2.	**Sandstone, Keystone,** gray, massive, coarse, cliff rock (3190′ B.)	55	70	70
3.	Concealed, with yellow soil and shale fragments colored black by manganese; spring at base (3170′ B.)	20	90	
Mauch Chunk Series—Bluestone Group (500′)				
4.	Shale, red	40	130	
5.	Shale, yellow	25	155	
6.	Shale, red	20	175	
7.	Concealed	55	230	
8.	**Sandstone, Upper Belcher,** greenish-gray, partly concealed (3005′ B.)	25	255	185
9.	Concealed	20	275	
10.	**Shale, Upper Belcher,** red	20	295	
11.	Concealed, with greenish-gray sandstone and sandy shale	285	580	
12.	**Shale, Pride,** dark, to top of Princeton Conglomerate (2670′ B.)	10	590	335
	Section continued with exposures along mountain road from top of Keeney Mountain down to Hinton:			
Mauch Chunk Series—Princeton Conglomerate (40′)				
13.	**Sandstone, Princeton,** massive, pebbly, cliff rock (2480′ B.)	40	630	40
Mauch Chunk Series—Hinton Group (1055′)				
14.	Concealed	40	670	
15.	**Shale, Pluto,** greenish-gray	20	690	
16.	Concealed	24	714	
17.	Slate, black, **coaly, Pluto Coal,** supplied from exposure at spring of Coleman Plumley (**Prospect No. 764 on Map VI**) on east side of Keeney Mountain 1.6 miles east of Hinton (0′ 9″)	1	715	85
18.	Concealed	5	720	
19.	Sandstone	5	725	
20.	Shale, yellowish-green	15	740	
21.	Sandstone, shaly (2355′ B.)	15	755	
22.	Shale, dark	10	765	
23.	**Shale, Lower Pluto,** greenish-yellow, (2335′ B.); contains numerous marine fossils, pelecypods	10	775	
24.	Shale, red	15	790	
25.	**Sandstone, Falls Mills,** shaly	5	795	80

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
26.	**Shale, Falls Mills,** red	47	842	
27.	**Sandstone, Tallery,** massive	3	845	50
28.	Shale, green, sandy, with streaks of red	58	903	
29.	**Limestone, Tallery,** greenish-yellow (2205′ B.); contains marine fossils, pelecypods	2	905	
30.	Shale, sandy ..24′ } **Upper**			
31.	Shale, red ..10 } **Tallery**	34	939	
32.	**Limestone, Low Gap,** yellow, sandy (2170′ B.)	1	940	
33.	**Shale, Low Gap,** sandy	10	950	
34.	**Sandstone, Avis,** shaly	15	965	120
35.	**Shale, Upper Avis,** green, sandy	25	990	
36.	**Shale, Upper Avis** (continued), yellow, calcareous, with marine fossil fragments.	15	1005	
37.	**Limestone, Avis,** steel-gray, somewhat shaly (2065′ B.); contains numerous marine fossils, brachiopods, pelecypods, gastropods, crinoids, and bryozoa	40	1045	80
38.	**Shale, Lower Avis,** yellow, calcareous (2050′ B.); contains marine fossils, brachiopods and pelecypods, both numerous	15	1060	
39.	Shale, red ..135		1195	
40.	**Sandstone, Hackett,** reddish-brown, shaly (1905′ B.)	10	1205	160
41.	Shale, red ..100′ }			
42.	Sandstone, red, shaly.... 5 } **Hackett**			
43.	Shale, red ..40 } **Shale** 164		1369	
44.	Sandstone, shaly ..10 }			
45.	Shale, sandy .. 9 }			
46.	Shale, yellow, calcareous, horizon of **Tophet Limestone**	1	1370	
47.	**Shale, Upper Tophet,** red, with streaks of sandstone	35	1405	
48.	**Sandstone, Tophet,** shaly (1690′ B.)	15	1420	215
49.	**Shale, Lower Tophet,** red	20	1440	
50.	Shale, sandy, horizon of **Goodwyn Sandstone**	5	1445	
51.	Limestone, yellow, shaly } **Lower**			
	(1660′ B.) .. 5′ } **Goodwyn**			
52.	Shale, red ..25 } **Shale**	30	1475	
53.	**Sandstone, Upper Bellepoint,** greenish-gray, coarse (1605′ B.)	30	1505	85
54.	Shale, variegated.....13′ }			
55.	Limestone, nodular, shaly } **Upper**			
	(1590′ B.) .. 2 } **Bellepoint**			
56.	Shale, red and variegated. 25 } **Shale**	40	1545	
57.	**Sandstone, Middle Bellepoint,** brown	10	1555	
58.	Shale, red, variegated	7	1562	
59.	**Limestone, Middle Bellepoint,** yellow, shaly, with marine fossil fragments (1545′ B.)	3	1565	
60.	**Shale, Middle Bellepoint,** red and variegated	35	1600	
61.	**Sandstone, Lower Bellepoint,** shaly	5	1605	100
62.	**Shale, Lower Bellepoint,** green and sandy (1470′ B.); contains marine fossils at top, pelecypods	35	1640	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
63.	**Sandstone, Stony Gap (Hinton** of Stevenson), white, massive, coarse, makes cliff along C. & O. Ry., just south of Hinton Station (1425′ B.)	45	1685	80
Mauch Chunk Series—Bluefield Group (75′)				
64.	**Limestone, Coney** (type locality), shaly	2	1687	
65.	**Shale, Coney** (type locality), green, sandy, (1418′ B.); contains marine fossils, pelecypods	5	1692	
66.	**Shale, Coney** (continued), red	5	1697	
67.	**Shale, Coney** (continued), red, variegated, and sandy, with a zone of plant fossils, to C. & O. Ry. (see **Lot 244,** collected in C. & O. cut just south of highway crossing)	31	1728	
68.	Concealed to New River 0.4 mile south of Hinton Station (1350′ B.)	32	1760	

The above section affords a complete view of the Hinton Group of the Mauch Chunk Series, being its type locality as defined by M. R. Campbell in the Pocahontas Folio, No. 26, of the United States Geological Survey. It is also the type locality of the **Hinton Sandstone** of Dr. John J. Stevenson, as exhibited in No. 63 of section, and the name Hinton Sandstone as applied to the individual member far antedates its use as a group name, but the latter usage has become so firmly fixed that unnecessary confusion would be caused by any attempt to revive the former except in a parenthetic sense. The sandstone is accordingly given a different name from its great exposure at Stony Gap in Mercer County, as will be later detailed.

The section also reveals a good exposure of the Avis Limestone that may be considered as its type locality, although no collection of fossils was made at this point and the collection made between the junction of New and Greenbrier Rivers has been designated as the type collection, as indicated in the Bellepoint Section which next follows.

Near the base of the section a very good exposure of the shales at the base of the Stony Gap Sandstone is presented in the deep cut of the Chesapeake and Ohio Railway, there being abundant plant fossils in addition to pelecypods. These are named the Coney Shale, as will be later detailed.

The following section was measured and the marine collections made by the writer in the angle between New and

Greenbrier Rivers, the fossils having been studied by Dr. Girty:

Bellepoint Section.

Greenbrier District, Summers County; starting at the north end of Wolf Creek Mountain 1.5 miles southeast of Bellepoint and extending northwestward down road to junction of Greenbrier with New River at Bellepoint; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Princeton Conglomerate (60′)				
1.	**Sandstone, Princeton,** massive, cliff rock, very pebbly, somewhat ferruginous (2465′ B.)	60	60	60
Mauch Chunk Series—Hinton Group (1085′)				
2.	**Shale, Pluto,** sandy, and concealed	15	75	
3.	**Shale, Pluto** (continued), (including **Terry Limestone** horizon), dark, fissile 2435′ B.); contains marine fossils, chiefly brachiopods (especially **Productus**) and pelecypods (see **Lot 189**)	15	90	
4.	Concealed	60	150	
5.	**Shale, Lower Pluto,** green, aluminous (2360′ B.); contains marine fossils, chiefly pelecypods (see **Lot 190**)	15	165	
6.	**Shale, Lower Pluto** (continued), sandy (2345′ B.); contains marine fossils, chiefly pelecypods (mostly **Myalina**) (see **Lot 191**)	20	185	
7.	**Shale, Lower Pluto** (continued), dark (2325′ B.); contains numerous marine fossils, pelecypods (chiefly **Myalina**) (see **Lot 192**)	15	200	
8.	Fire clay **shale, Lower Pluto** (continued), gray, with plant fossils (2320′ B.)	5	205	
9.	**Shale, Lower Pluto** (continued), sandy	10	215	
10.	**Sandstone, Falls Mills,** greenish-gray, massive, hard, cliff rock (2270′ B.)	40	255	195
11.	**Shale, Falls Mills,** red and green, sandy	4	259	
12.	**Limestone, Falls Mills,** shaly (2265′ B.); contains marine fossils, pelecypods and great profusion of ostracods (see **Lot 193**)	1	260	
13.	**Shale, Upper Fivemile,** green and variegated (2260′ B.); contains marine fossils, pelecypods and ostracods (see **Lot 194**)	5	265	
14.	Shale, dark, with fire clay spring, **Fivemile Coal** horizon	5	270	
15.	**Shale, Lower Fivemile,** green, sandy (2226′ B.); contains marine fossils at base, pelecypods (especially **Myalina**), ostracods and annelids (**Spirorbis**) (see **Lot 195**)	29	299	
16.	**Limestone, Tallery,** hard, sandy	1	300	
17.	**Shale, Upper Tallery,** sandy	10	310	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
18.	**Shale, Upper Tallery** (continued), green, calcareous, (2202′ B.); contains numerous marine fossils, largely pelecypods (especially **Myalina**) (see **Lot 195**).....	13	323	
19.	Shale, sandy, with plant fossils, horizon of **Tallery Coal**	2	325	
20.	**Shale, Lower Tallery,** green, sandy, with a little limestone	38	363	
21.	**Limestone, Low Gap,** yellow, shaly, and sandy	2	365	
22.	**Shale, Low Gap,** red and yellow.....	10	375	
23.	**Sandstone, Avis,** shaly.....	25	400	145
24.	**Shale, Upper Avis,** green, calcareous (2085′ B.); contains numerous marine fossils, pelecypods (especially **Myalina**) (see **Lot 197**—type collection).....	40	440	
25.	**Limestone, Avis,** partly gray and hard and partly yellow and shaly (2040′ B.); contains abundant and varied marine fossils, brachiopods, pelecypods, gastropods, and bryozoa (see **Lot 198**—type collection)...	45	485	85
26.	**Shale, Lower Avis,** yellow, limy (2025′ B.); contains numerous marine fossils, largely pelecypods with some brachiopods and ostracods (see **Lot 199**—type collection)..	15	500	
27.	**Sandstone, Payne Branch,** reddish-brown..	5	505	
28.	Shale, red .....30′			
29.	Shale, yellow 10			
30.	Shale, red 35	**Payne Branch** ...	90	595
31.	Sandstone, shaly 5			
32.	Shale, red 10			
33.	**Sandstone, Hackett,** shaly.....	10	605	
34.	Shale, red .....30′			
35.	Sandstone, massive.....10			
36.	Shale, red.....65	**Hackett Shale** 159		764
37.	Sandstone, shaly 5			
38.	Shale, red 49			
39.	**Limestone, Tophet,** shaly (1760′ B.).....	1	765	
40.	**Shale, Upper and Lower Tophet,** red.....120		885	
41.	**Sandstone, Goodwyn,** shaly.....	15	900	
42.	**Shale, Lower Goodwyn,** sandy.....	40	940	
43.	**Sandstone, Upper Bellepoint,** greenish-brown, massive (1545′ B.)	40	980	495
44.	**Shale, Upper Bellepoint,** variegated.....	35	1015	
45.	**Sandstone, Middle Bellepoint**.....	5	1020	
46.	**Shale, Middle Bellepoint,** red and variegated, sandy	40	1060	
47.	**Sandstone, Lower Bellepoint,** somewhat shaly (1455′ B.)	10	1070	90
48.	**Shale, Lower Bellepoint,** green, sandy (1420′ B.); contains marine fossils at top, pelecypods and ostracods (see **Lot 200**—type locality)	35	1105	
49.	**Sandstone, Stony Gap (Hinton** of Stevenson), locally shaly	40	1145	75

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluefield Group (20′)			
50. Concealed and sandstone, containing shale breccia, to Greenbrier River at Bellepoint (1360′ B.)	20	1165	

The above section, also, gives an excellent view of the Hinton Group in the region of its type locality, there being many zones of marine fossils from which collections are now available. Taken in conjunction with the exposures of the Hinton Section a more complete record of such a thick group of rocks could hardly be found.

MEASURED SECTIONS, TALCOTT DISTRICT, SUMMERS COUNTY.

Talcott District lies in the eastern end of Summers, next to Greenbrier and Monroe Counties, its area being drained by Greenbrier River. The surface rocks range from the Pocahontas Group of the Pottsville Series of the Pennsylvanian down through the entire Mauch Chunk Series and into the top of the Greenbrier Series of the Mississippian. The structure in a few localities has dips of 10 to 15 degrees but in general it rises gently toward the southeast.

The following section, measured by the writer, indicates the succession near the eastern end of Big Bend Tunnel as exposed along the public highway just north of the railroad grade:

Talcott Section.

Talcott District, Summers County; starting on Hinton-Talcott road just north of the eastern portal of Big Bend Tunnel and traversing northeastward along the public road to Hungard Creek 0.7 mile northwest of Talcott; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (20′)			
1. **Sandstone, Stony Gap (Hinton** of Stevenson), white, massive, cliff rock (1705′ B.).	20	20	20
Mauch Chunk Series—Bluefield Group (215′)			
2. **Shale, Coney,** red and variegated, with plant fossil fragments; contains marine fossils at top, abundant small-sized pelecypods suggesting **Sphenotus,** also ostracods (see **Lot 225**)	75	95	
3. **Sandstone, Clayton,** shaly (1616′ B.)	14	109	89

			Thickness. Feet.	Total. Feet.	Intervals. Feet.
4.	Limestone, green, soft, shaly, with marine fossil fragments (1615′ B). 1′	Clayton Shale			
5.	Shale, variegated.....25				
6.	Sandstone, shaly 5				
7.	Shale, variegated, and concealed 45				
			76	185	
8.	**Sandstone, Graham,** shaly.....		10	195	86
9.	Concealed, horizon of **Upper Graham Shale**		30	225	
10.	**Sandstone, Bertha?,** shaly, to Hungard Creek at highway bridge (1490′ B.).....		10	235	

In Fossil Lot 225, collected by the writer, Dr. Girty reports small pelecypods, but at a subsequent visit to the same locality by Paul H. Price and the writer a zone of ostracods was found in the same shale, their presence in this Coney Shale being quite common at various localities.

The following section, measured by the writer, records intervals that are slightly less than true vertical measurement would show, there being a southeastward rise of about 100 feet in the structure for which a partial allowance was made in No. 30 of section. If a complete correction were possible it is not probable that the interval between the Princeton Sandstone and the Droop Sandstone would be increased more than 75 feet:

Pence Springs Section.

Talcott District, Summers County; starting at the road fork just southeast of Tampa and traversing northeastward to Clayton and thence southward along the Hungard Creek road to Pence Springs; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Princeton Conglomerate (35′)				
1.	**Sandstone, Princeton,** massive, pebbly (2830′ B.)	35	35	35
Mauch Chunk Series—Hinton Group (835′)				
2.	**Shale, Pluto,** green and sandy.....	95	130	
3.	**Shale, Lower Pluto,** red and sandy.....	50	180	
4.	**Sandstone, Falls Mills** (2615′ B.)..;..;....	70	250	215
5.	**Shale, Falls Mills,** green (2605′ B.); contains marine fossils, pelecypods.....	10	260	
6.	Shale, red and variegated.....	60	320	
7.	**Limestone, Avis,** steel-gray (2525′ B.); contains marine fossils, brachiopods, crinoids, and bryozoa	20	340	90
8.	**Shale, Lower Avis,** yellow, with marine fossils	20	360	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
9.	Shale, red	105	465	
10.	**Sandstone, Hackett,** shaly	10	475	
11.	**Shale, Hackett,** red	50	525	
12.	Shale, greenish-yellow, horizon of **Tophet Limestone**	15	540	
13.	Shale, red	135	675	
14.	**Sandstone, Upper Bellepoint,** shaly (2175′ B.)	15	690	350
15.	Shale, red, with streaks of green, partly concealed	140	830	
16.	**Sandstone, Stony Gap (Hinton** of Stevenson), gray, massive, slightly ferruginous, cliff rock (1995′ B.); outcrops along road at Clayton	40	870	180
	Mauch Chunk Series—Bluefield Group (480′)			
17.	**Shale, Coney,** reddish-brown (1985′ B.); contains marine fossils, pelecypods (chiefly **Myalina**), ostracods, and annelids (**Spirorbis**), (see **Lot 221**); also fucoidal	10	880	
18.	Shale, green, and concealed 10′			
19.	Shale, red 5	**Coney** (continued)	15	895
20.	**Sandstone, Clayton,** reddish-brown, shaly, makes cliff (1945′ B.)	25	920	50
21.	Shale, red 10′			
22.	Sandstone, shaly 5	**Clayton**		
23.	Shale, red, partly concealed 50	**Shale**	65	985
24.	**Sandstone, Graham,** shaly (1880′ B.)	15	1000	80
25.	**Shale, Upper Graham,** red, with thin sandstone	35	1035	
26.	Concealed, with sandstone	25	1060	
27.	Shale, sandy, with **plant fossils** and iron pyrites, horizon of **Graham Coal** (1800′ B.)	5	1065	
28.	**Shale, Lower Graham,** variegated, partly concealed	20	1085	
29.	**Sandstone, Bertha,** shaly	10	1095	95
30.	Concealed, with red shales, from point near Bush School to edge of plateau 0.7 mile farther south	30	1125	
31.	**Shale, Lower Bertha,** green (1695′ B.); contains marine fossils at base, pelecypods	45	1170	
32.	**Sandstone, Bradshaw,** green, hard, cliff rock (1685′ B.)	10	1180	85
33.	Shale, green 10′			
34.	Shale, red, with sandstone 30	**Bradshaw Shale**	41	1221
35.	Limestone, yellow, shaly. 1			
36.	Shale, variegated, very sandy, horizon of **Indian Mills Sandstone**	34	1255	
37.	Limestone, yellow 1′			
38.	Shale, variegated and sandy 14			
39.	Limestone, shaly (1590′ B.); contains marine fossils, pelecypods 5	**Indian Mills Shale**	20	1275

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
40.	Shale, green, calcareous, with streaks of hard limestone, **Raines Corner Limestone** (1555′ B.); marine fossils in limestone, brachiopods and gastropods (**Bellerophon**) (see **Lot 222**)	35	1310	130
41.	**Coal blossom, Raines Corner,** streak (1555′ B.), (**Exposure No. 791 on Map VI**)	..	1310	
42.	**Sandstone, Droop,** shaly, to road fork at foot of hill (1535′ B.)	20	1330	
43.	Concealed, with flaggy sandstone, to Greenbrier River at Pence Springs bridge (1515′ B.)	20	1350	

A very good view of the Princeton and Hinton and most of the Bluefield Group of the Mauch Chunk is afforded in the above section, collections having been made by Dr. Girty and the writer at the Coney Shale and Raines Corner Limestone horizons, showing the ostracods which are common in the former and the gastropod **Bellerophon** that is almost invariably present in the latter.

The following section, measured by the writer, with the assistance of Paul H. Price in the collection of Lot 245 and of Dr. Girty at Lots 220 and 219, and with fossil identifications by the latter, indicates the succession from the vicinity of Clayton School eastward down Griffith Creek:

Glenray Section.

Talcott District, Summers County; starting at the top of a knob 0.2 mile east of Clayton and traversing northward to Clayton School and thence eastward along road to Griffith Creek; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (175′)				
1.	Shale, red, from top of knob	15	15	
2.	Shale, greenish-yellow	15	30	
3.	Concealed, mostly red shale, to road summit just north of Clayton School (2120′ B.)	120	150	
4.	**Shale, Lower Bellepoint,** variegated	15	165	
5.	**Sandstone, Stony Gap (Hinton** of Stevenson), shaly (2095′ B.)	10	175	175
Mauch Chunk Series—Bluefield Group (680′)				
6.	**Shale, Coney,** green, partly concealed across glade on rise of strata, estimated. (This section starts again at the eastern end of the glade with the base of No. 6 at elevation 2105′ B.):	25	200	
7.	**Shale, Coney** (continued), red	25	225	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
8.	**Sandstone, Clayton** (type locality), reddish-brown, massive, hard, with smooth texture and medium grain, quarry rock of Alderson Brownstone Company (2050′ B.)	30	255	80
9.	**Shale, Clayton** (type locality), variegated, mostly red; marine fossils in upper portion, pelecypods (especially **Sphenotus**), (see **Lot 245**, collected from a zone 10 to 20 feet below top)	95	350	
10.	Shale, yellowish-green, sandy	10	360	
11.	Shale, red, partly concealed	90	450	
12.	**Sandstone, Bertha**, white, massive, makes cliff (1840′ B.)	15	465	210
13.	**Shale, Upper Bertha**, sandy, partly concealed	15	480	
14.	**Sandstone, Bradshaw**, shaly (1810′ B.)	15	495	
15.	Shale, red .....95′ } **Bradshaw** ...100		595	
16.	Shale, green ..... 5 }			
17.	**Coal blossom, Red Sulphur**, streak (1710′ B.) (**Exposure No. 776 on Map VI**)	..	595	
18.	**Limestone, Raines Corner**, shaly (1705′ B.) contains marine fossils, gastropods (**Bellerophon**) and brachiopods (see **Lot 220**)	5	600	135
19.	Concealed	15	615	
20.	**Sandstone, Droop**, partly massive and partly shaly, but mostly concealed, along creek at foot of hill (1610′ B.)	85	700	100
21.	**Shale, Talcott**, green, with streaks of impure limestone	15	715	
22.	**Limestone, Reynolds**, very shaly, with marine fossils, numerous large pelecypods, also brachiopods	25	740	
23.	Concealed	35	775	
24.	**Sandstone, Webster Springs**, massive	5	780	80
25.	**Limestone, Glenray** (type locality), gray, hard, sandy, and impure; makes cliffs along Greenbrier River at the mouth of Griffith Creek opposite Glenray; contains marine fossils, brachiopods, crinoids, and bryozoa (fairly abundant **Archimedes**), (see **Lot 219**)	75	855	75

This very important section indicates the type localities of the Clayton Sandstone, Clayton Shale, and Glenray Limestone, together with their stratigraphic associations in the Bluefield Group, and the Raines Corner Limestone is exposed, carrying **Bellerophon** as usual. There is an eastward structural rise of about 600 feet along the line of traverse, however, only a small portion of which has been eliminated, so that the published intervals are far short of those which true vertical measurement would show.

The following section, measured by the writer, is located in the edge of Talcott District, Summers County, although named for the town of Alderson which is partly in Monroe and partly in Greenbrier County and only one mile and a half from the base of the section:

Alderson Section.

Talcott District, Summers County; starting at the top of Keeney Knob on Keeney Mountain and traversing southeastward to Mt. Zion Church and thence southward down Possum Hollow to its junction with Greenbrier River 1.5 miles west of Alderson; dip northwest about 100 feet per mile; arrangement in descending stratigraphic order; **Nos. 1-70,** inclusive, were measured with aneroid but the apparent thicknesses of these members were increased approximately 12½ per cent., or a total of 280 feet, to show a true vertical section; **Nos. 71 to 79,** inclusive, were measured by separate determination or by estimate.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Pottsville Series—Pocahontas Group (90′)			
1. **Sandstone, Lower Pocahontas,** gray, forms top of Keeney Knob (3925′ B.)	22	22	22
2. Concealed in slope, with yellow sandy soil	45	67	
3. **Sandstone, Keystone,** buff	23	90	68
Mauch Chunk Series—Bluestone Group (663′)			
4. Shale, yellow, sandy, with plant fossils (3845′ B.)	22	112	
5. Sandstone, greenish-gray, flaggy (3840′ B.)	6	118	28
6. Shale, red	73	191	
7. Sandstone, brown, shaly, micaceous	17	208	90
8. Shale, red	62	270	
9. Concealed	56	326	
10. **Sandstone, Bent,** massive, coarse, buff, micaceous, cliff rock (3610′ B.)	50	376	168
11. Shale, red, largely concealed, to highest road fork (2410′ B.)	225	601	
12. Concealed	56	657	
13. **Shale, Lower Mud,** variegated	28	685	
14. **Sandstone, Glady Fork,** shaly	11	696	
15. Concealed, with dark shale, **Pride Shale** (3275′ B.)	57	753	
Mauch Chunk Series—Princeton Conglomerate (35′)			
16. **Sandstone, Princeton,** gray, massive, coarse, pebbly (3245′ B.)	35	788	412
Mauch Chunk Series—Hinton Group (849′)			
17. Concealed	90	878	
18. **Shale, Lower Pluto,** sandy	17	895	
19. Shale, red	51	946	
20. **Sandstone, Falls Mills,** greenish-brown, shaly (3090′ B.)	17	963	175
21. Shale, red, and variegated	80	1043	
22. **Sandstone, Avis,** green, flaggy, cliff rock (2995′ B.)	30	1073	
23. Shale, red	16	1089	

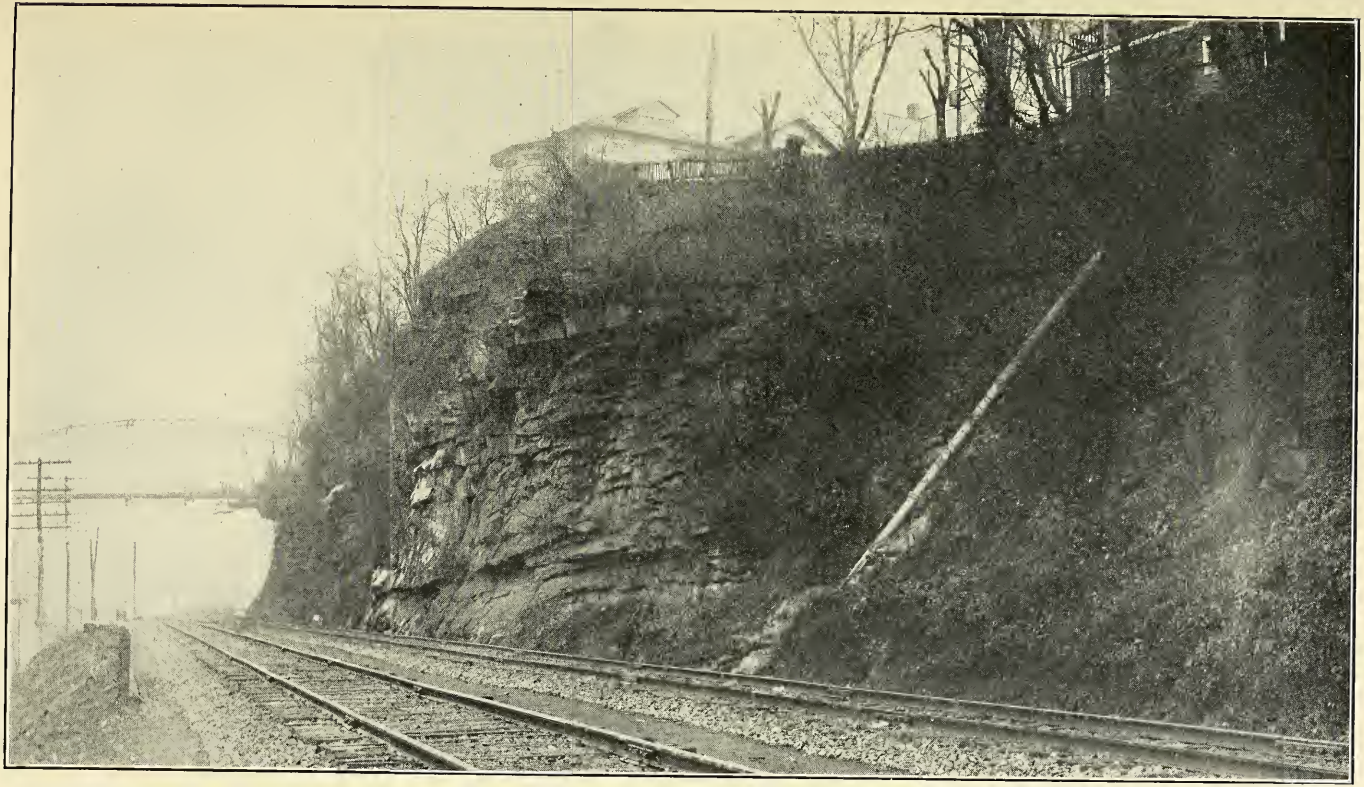


PLATE XIV—Stony Gap Sandstone (Hinton of Stevenson) in cut of Chesapeake and Ohio Railway along east side of New River just south of station at Hinton, Summers County. (Photo. by Palmer & Fowler).

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
24.	**Shale, Upper Avis,** greenish-yellow, limy, with marine fossils, pelecypods	11	1100	
25.	**Limestone, Avis,** steel-gray, shaly at middle, with numerous marine fossils, pelecypods, brachiopods, gastropods, crinoids, and bryozoa (2915′ B.)	28	1128	165
26.	**Shale, Lower Avis,** yellow, calcareous	33	1161	
27.	Shale, red	170	1331	
28.	**Sandstone, Goodwyn,** reddish-brown, shaly, (2755′ B.)	11	1342	
29.	**Shale, Lower Goodwyn,** red	72	1414	
30.	**Sandstone, Upper Bellepoint,** reddish-brown, with massive layers interbedded with shale (2645′ B.)	50	1464	336
31.	**Shale, Upper Bellepoint,** variegated	23	1487	
32.	**Sandstone, Middle Bellepoint,** shaly, reddish-brown (2595′ B.)	34	1521	57
33.	**Shale, Middle Bellepoint,** red, partly concealed	39	1560	
34.	**Sandstone, Lower Bellepoint,** massive, reddish-brown (2550′ B.)	11	1571	50
35.	**Shale, Lower Bellepoint,** red and variegated	49	1620	
36.	**Sandstone, Stony Gap (Hinton of Stevenson),** massive at base, cliff rock (2490′ B.)	17	1637	66
Mauch Chunk Series—Bluefield Group (1202′)				
37.	Shale, calcareous, with restricted fauna; ostracods and annelids (**Spirorbis**) 6′			
38.	Sandstone, shaly 6			
39.	Shale, variegated 5	**Coney Shale.** 73	1710	
40.	Sandstone, shaly 11			
41.	Shale, variegated 28			
42.	Sandstone, shaly 6			
43.	Shale, green, sandy, partly concealed 11			
44.	**Sandstone, Clayton,** greenish, massive, cliff rock (2415′ B.)	11	1721	84
45.	**Shale, Clayton,** variegated and limy	37	1758	
46.	**Sandstone, Graham,** greenish-brown, shaly at top (2372′ B.)	11	1769	
47.	Shale, variegated	2	1771	
48.	**Limestone, Graham,** yellow, shaly (2365′ B.)	6	1777	
49.	Shale, variegated	9	1786	
50.	Sandstone, brown, shaly	2	1788	
51.	Shale, red	4	1792	
52.	**Limestone, Graham** (continued), yellow, earthy, and brecciated (2350′ B.)	2	1794	
53.	Shale, red	11	1805	
54.	Sandstone, reddish-brown, shaly (2330′ B.)	11	1816	
55.	Shale, red and green	23	1839	
56.	**Sandstone, Bertha,** shaly	6	1845	
57.	**Shale, Upper Bertha,** yellowish-green, calcareous, with marine fossils (2290′ B.), numerous pelecypods	17	1862	141
58.	Shale, red and variegated	39	1901	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
59.	Sandstone, reddish-brown, shaly (2250′ B.).	6	1907	
60.	Shale, red	11	1918	
61.	Shale, green	6	1924	
62.	Shale, red	6	1930	
63.	Sandstone, reddish-brown, shaly (2225′ B.).	6	1936	
64.	**Shale, Lower Bertha,** red, streaked with green	88	2024	
65.	Shale, sandy, horizon of **Bradshaw Sandstone**	40	2064	
66.	**Shale, Bradshaw,** red and variegated, sandy	96	2160	
67.	**Sandstone, Indian Mills,** shaly (2005′ B.), outcrops at Mt. Union Church	22	2182	320
68.	Shale, red and variegated, partly concealed	165	2347	
69.	Sandstone, flaggy, cliff rock (1845′ B.)	17	2364	182
70.	Shale, red and variegated, partly concealed	135	2499	
71.	**Limestone** boulders, **Raines Corner** (1725′ B.)	..	2499	135
72.	Concealed (estimated)	50	2549	
73.	**Sandstone, Droop,** shaly, cliff rock	25	2574	75
74.	**Shale, Talcott,** green, sandy	15	2589	
75.	**Shale, Ada,** green, limy, with marine fossils, brachiopods (**Spirifer pellaensis, Productus inflatus,** etc.), and bryozoa; (estimated)	60	2649	
76.	Concealed, horizon of **Reynolds Limestone** (estimated)	15	2664	90
77.	**Limestone, Glenray,** shaly and sandy (estimated)	75	2739	
78.	**Shale, Lillydale ("Pencil Cave"),** black and green, fissile, (estimated)	100	2839	175
Greenbrier Series (30′)				
79.	**Limestone, Alderson,** hard, yellowish-blue, with marine fossils, bryozoa (**Archimedes**), etc., visible above Greenbrier River at mouth of Possum Hollow	30	2869	

In the above section the full thickness of the Mauch Chunk Series is exhibited at the only point in the three counties where it can be successfully measured at a continuous exposure, and nearly all of its most persistent and easily recognized members are plainly visible. The total thickness of 2,749 feet, however, is 489 feet less than the combined total of 3,238 feet obtained at two or three localities and combined in the Stony Gap Section near Princeton and Bluefield where an uncertain portion of the top is eroded from the series; and it is 701 feet less than the estimated maximum in that region. This decrease in thickness continues northward through other counties until the series almost, if not totally,

disappears in some of the northwestern counties, and is only 400 feet thick along the Chestnut Ridge Anticline in Monongalia County.

At the top of the section a poorly exposed remnant of the Pocahontas Group of the Pottsville is preserved in the top of Keeney Knob but no coals were observed and it appears that the cap rock of the mountain is the Lower Pocahontas Sandstone which directly underlies the No. 3 Pocahontas Coal so that no valuable seams will likely be found. At the base of the section a very clear contact of the Mauch Chunk and Greenbrier Series is visible at the mouth of Possum Hollow.

MEASURED SECTIONS, FOREST HILL DISTRICT, SUMMERS COUNTY.

Forest Hill District occupies a portion of Summers County south of the Big Bend of Greenbrier River, east of New River and next to the Monroe County line. Its bedded surface rocks are wholly confined to the Mauch Chunk Series of the Mississippian; and of this series there is only a remnant of the Bluestone Group, and the basal portion of the Bluefield Group is under drainage. The rock structure of the district is monoclinal, rising gently toward the southeast. Some very good exposures are afforded along New River and its major tributaries.

The following section, measured by the writer, contains a westward dip of approximately 125 feet along the line of its traverse so that the total thicknesses are excessive to that extent:

Bertha Section.

Forest Hill District, Summers County; starting at a triangulation point on Wolf Creek Mountain 0.5 mile southeast of Low Gap School and extending northwestward to this school and thence westward down road to New River at Bertha; gentle northwest dip; measured with aneroid; arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Princeton Conglomerate (25′)			
1. **Sandstone, Princeton,** gray, massive, hard, coarse, slightly ferruginous, makes top of knob (2850′ B.)	25	25	25

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (1050′)				
2.	Concealed	105	130	
3.	**Shale, Lower Pluto,** dark-green, fissile (2705′ B.); contains marine fossils, pelecypods	40	170	
4.	Shale, variegated	30	200	
5.	Concealed, with sandstone	40	240	
6.	**Sandstone, Falls Mills**	20	260	235
7.	Shale, sandy, and concealed	90	350	
8.	**Shale, Lower Tallery,** variegated	25	375	
9.	**Sandstone, Low Gap,** shaly	20	395	
10.	Shale, green	3	398	
11.	**Limestone, Low Gap,** (type locality), yellow, shaly, with marine fossil fragments (2475′ B.)	2	400	140
12.	**Shale, Low Gap,** (type locality), red and variegated	10	410	
13.	**Sandstone, Avis,** shaly	5	415	
14.	**Shale, Avis,** green, partly concealed, with marine fossils, pelecypods	25	440	
15.	**Limestone, Avis,** massive at top, shaly at base (2395′ L.); contains marine fossils, crinoids and brachiopods	40	480	80
16.	**Shale, Lower Avis,** yellow, calcareous	15	495	
17.	Shale, red	70	565	
18.	**Sandstone, Payne Branch,** shaly	10	575	
19.	**Shale, Payne Branch,** red	20	595	
20.	**Sandstone, Hackett,** reddish-brown, massive, (2255′ B.)	25	620	
21.	Shale, **Hackett,** red	30	650	
22.	Sandstone, reddish-brown, shaly (2200′ B.)	25	675	
23.	**Shale, Upper Tophet,** red	50	725	
24.	**Sandstone, Tophet**	3	728	
25.	**Shale, Lower Tophet,** red	47	775	
26.	**Sandstone, Goodwyn,** shaly (2065′ B.)	35	810	330
27.	Shale, yellow, sandy 25′			
28.	Shale, red 45			
29.	Shale, greenish-yellow 35	Upper and Lower Goodwyn 140	950	
30.	Shale, red 35			
31.	**Sandstone, Upper Bellepoint,** shaly	5	955	145
32.	**Shale, Upper Bellepoint,** red	10	965	
33.	**Sandstone, Middle Bellepoint,** shaly (1895′ B.)	15	980	25
34.	**Shale, Middle Bellepoint,** red	40	1020	
35.	**Sandstone, Lower Bellepoint,** shaly	10	1030	50
36.	Shale, red and variegated 15′			
37.	Limestone, yellow, shaly (1825′ B.) 5	Lower Bellepoint Shale 25	1055	
38.	Shale, red 5			
39.	**Sandstone, Stony Gap** (Hinton of Stevenson), shaly (1800′ B.)	20	1075	45
Mauch Chunk Series—Bluefield Group (405′)				
40.	**Shale, Coney,** red	65	1140	
41.	Shale, yellow	35	1175	
42.	Shale, red	10	1185	
43.	Concealed	50	1235	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
44.	Shale, sandy	35	1270	
45.	Shale, red	5	1275	
46.	Sandstone, Bertha (type locality), shaly (1555′ B.)	45	1320	245
47.	Concealed to New River at Bertha (1395′ B.)	160	1480	

At the locality of the above section the great Stony Gap Sandstone at the base of the Hinton Group becomes shaly and differs but little in texture from the other ledges above and below it and the same condition continues for several miles southeastward up New River, yet its approximate position can not be far mistaken since the Avis Limestone is generally visible higher up on the mountains, being 595 feet above the base of the Stony Gap at this particular locality. This particular section is the type locality of the Bertha Sandstone which is here weathered to a somewhat shaly condition but which elsewhere is often massive and hard. Farther up in the mountain the Low Gap Sandstone, Low Gap Limestone, and Low Gap Shale are typically displayed along the highway above Low Gap School.

In the following section, the surface portion was measured by the writer but the lower part is the record of the **George Harmon No. 1 Well (14)**, as furnished by Charles H. Mellon, of Philadelphia, Pennsylvania, and as previously published by Dr. I. C. White on pages 504-505 of Volume I(a) of the Survey, its location being on the flood-plain of New River slightly southeast of the base of the measured section:

Warford Section.

Forest Hill District, Summers County; starting at a high point near the southern end of Wolf Creek Mountain 1.6 miles southeast of Bertha and extending southwestward via Buffalo Creek to the **George Harmon No. 1 Well (14);** gentle northwest dip; surface portion measured with aneroid along the strike and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Princeton Conglomerate (35′)				
1.	**Sandstone, Princeton,** gray, massive, coarse, hard (2830′ B.)	35	35	35
Mauch Chunk Series—Hinton Group (970′)				
2.	Concealed by debris	45	80	
3.	**Shale, Pluto,** sandy	65	145	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
4.	**Shale, Lower Pluto,** etc., red and variegated	100	245	
5.	**Sandstone, Tallery,** massive	55	300	265
6.	Concealed and sandy shale	75	375	
7.	**Sandstone, Avis,** shaly and flaggy, makes cliff (2480′ B.)	10	385	
8.	**Shale, Upper Avis,** yellowish-green	30	415	
9.	**Limestone, Avis,** steel-gray, shaly, weathering yellow (2420′ B.); contains marine fossils, crinoids, brachiopods (**Orthotetes, Composita,** etc.), and bryozoa (including **Archimedes**)	30	445	145
10.	**Shale, Lower Avis,** yellow, calcareous, with marine fossils	20	465	
11.	**Shale, Lower Avis** (continued), red	35	500	
12.	**Sandstone, Payne Branch,** reddish-brown, shaly	10	510	
13.	**Shale, Payne Branch,** red	15	525	
14.	**Sandstone, Hackett,** shaly	20	545	
15.	**Shale, Hackett,** variegated, but mostly red	290	835	
16.	**Sandstone, Upper Bellepoint,** shaly, makes cliff (2005′ B.)	25	860	415
17.	Shale, variegated, partly concealed	135	995	
18.	**Sandstone, Stony Gap** (Hinton of Stevenson), shaly, makes cliff (1860′ B.)	10	1005	145
Mauch Chunk Series—Bluefield Group (1350′)				
19.	Shale, variegated, partly concealed	275	1280	
20.	**Sandstone, Bertha,** greenish-gray, shaly, makes cliff (1550′ B.)	35	1315	310
21.	**Shale, Upper Bertha,** sandy	13	1328	
22.	**Limestone, Bertha,** yellowish, impure (1535′ B.); contains marine fossils, bryozoa, etc.	2	1330	15
23.	Sandstone, shaly	15	1345	
24.	Shale, greenish-yellow, sandy 25′			
25.	Limestone, yellow, shaly, with marine fossil fragments (1490′ B.) 5	**Lower Bertha Shale**	60	1405
26.	Shale, variegated 30			
27.	**Sandstone, Bradshaw,** to level of well (1430′ B.)	30	1435	105
	Section continued with record of **George Harmon No. 1 Well** (14), located in Crumps Bottom on south side of New River 1.6 miles east of Warford:			
28.	Unrecorded	95	1530	
29.	Shale, gray, limy	30	1560	
30.	**Sandstone, Indian Mills,** gray, pebbly	75	1635	200
31.	Shale, red	100	1735	
32.	**Sand, Maxton (Droop),** dark-gray	60	1795	160
33.	Sandy beds, dark	290	2085	
34.	Limy beds, bluish-gray, **Little Lime (Glenray Limestone)**	50	2135	
35.	**Sandstone, Edray,** greenish-gray	190	2325	
36.	Shale, red, sandy, **Pencil Cave (Lillydale Shale)**	30	2355	560

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Greenbrier Series (1415')				
37. Limestone, gray .....18'				
38. Limestone, dark 7	Alderson ...220		2575	220
39. Limestone, dark, slaty..195				
40. Limestone, dark-gray, slaty ..... 15'	Union 185		2760	185
41. Limestone, dark-gray ...170				
42. Shale, red.....		65	2825	
43. Limestone, dark-gray....435'				
44. Limestone, light-gray.... 65	Pickaway and			
45. Limestone, dark-gray.... 95	Patton 600		3425	665
46. Limestone, light-gray.... 5				
47. Limestone, steel-gray, Sinks Grove and Hillsdale		345	3770	345
Maccrady Series (127')				
48. Shale, red, sandy.....		60	3830	
49. Shale, gray, sandy.....		15	3845	
50. Sandy beds, purple.....		52	3897	
Pocono Series (538')				
51. Sandstone, grayish-white 8'				
52. Shell, with gas (little).. 22				
53. Sandstone, dark-gray.... 18				
54. Sandstone, gray..... 15				
55. Sandstone, hard, brown. 10				
56. Sandstone, hard, dark-brown 15	Big Injun Sand 128		4025	255
57. Sandstone, hard, dark, shelly 5				
58. Shale, dark, sandy..... 15				
59. Sand, shells, and quartz pebbles 20				
60. Sandy beds, gray.....		35	4060	
61. Shales, sandy, dark-gray.....		60	4120	
62. Sandstone, dark, shaly, with coal streak, Squaw Sand.....		9	4129	104
63. Sandy beds, dark, shaly.....		11	4140	
64. Shale, gray, sandy.....		15	4155	
65. Sandstone, gray, shaly, Weir Sand.....		35	4190	61
66. Shale, dark-gray, sandy.....		45	4235	
67. Sandy beds, green.....		25	4260	
68. Sandy beds, dark-gray, Coffee (Sunbury) Shale		20	4280	
69. Sandstone, gray, hard... 15'				
70. Sandstone, dark-gray.... 40				
71. Sandstone, grayish-white 25				
72. Sandstone, grayish..... 20	Berea			
73. Sandstone, white, mixed with dark slate..... 10	Sand 130		4410	220
74. Sandstone, grayish-white, mixed with dark slate. 20				
75. Slate, dark, with sandstone.....		25	4435	

In the above section the position of the Stony Gap Sandstone, by its average interval, would belong in the partly concealed interval represented by No. 19 but there is scarcely

a vestige of hard rock in the whole 275 feet so that the Stony Gap has either thinned away completely or else it is represented by the shaly ledge of No. 18 which makes a prominent cliff around the side of the mountain. The latter interpretation is favored by the writer and is so indicated in spite of the slightly decreased interval below the base of the Avis Limestone.

In the subsurface portion the presence of pebbles in the Indian Mills Sandstone is anomalous, if correctly reported by the driller, since quartz pebbles are almost totally, if not wholly, absent in the Mauch Chunk Series of the three counties, except those which occur in great abundance in the Princeton Conglomerate. The presence of such a thick bed of sandstone as that noted in No. 35 is also quite irregular, this interval being usually occupied by the Glenray Limestone toward the top and by the black Lillydale Shale toward the base, although the lenticular Edray Sandstone sometimes fills part of the lower portion. If the record is correct it would appear that a local swelling of this latter member has occurred. In the Greenbrier Series the only red shale of consequence that regularly occurs at outcrops in Monroe County is found in the two streaks above and below the Taggard Limestone coming between the Pickaway and Patton horizons. The 65 feet of red shale recorded in No. 42, however, appears to be too near the top of the series to represent the Taggard horizon and is probably only a lenticular streak.

Farther down in the section the Pocono Series exhibits much the same aspects as may be noted in thousands of oil and gas wells in the developed pools of the western part of the State, except that a trace of coal is found in the Squaw Sand. This coal is probably near the horizons of the Merrimac and Langhorne Coals of Virginia and of their less prominent counterparts in the outcropping Pocono of Monroe County.

The following section was measured by the writer, the fossils collected at Lot 165 having been studied by Dr. Girty:

Indian Mills Section.

Forest Hill District, Summers County; starting at edge of plateau 0.7 mile northwest of Indian Mills and traversing down hill road to Indian Creek at Indian Mills; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (195′)				
1.	Concealed from top of plateau	20	20	
2.	**Sandstone, Upper Bellepoint**, brown, massive, coarse (2200′ B.)	35	55	55
3.	Shale, red, sandy	75	130	
4.	**Sandstone, Lower Bellepoint**, shaly	25	155	100
5.	Shale, green, sandy, with marine fossils, pelecypods 5′			
6.	Shale, red and variegated, calcareous 5	**Lower Bellepoint**	30	185
7.	Sandstone, shaly 2			
8.	Shale, red and variegated. 18			
9.	**Sandstone, Stony Gap (Hinton of Stevenson)**, shaly (2060′ B.)	10	195	40
Mauch Chunk Series—Bluefield Group (590′)				
10.	Shale, yellow, calcareous, horizon of **Coney Limestone**	5	200	
11.	**Shale, Coney**, red and variegated	50	250	
12.	Concealed	20	270	
13.	**Sandstone, Clayton**, shaly	5	275	
14.	Shale, variegated 30′			
15.	Sandstone, shaly 5			
16.	Shale, green 20	**Clayton Shale**	95	370
17.	Sandstone, flaggy 10			
18.	Shale, greenish-yellow, sandy 30			
19.	**Sandstone, Graham**, shaly	5	375	
20.	Shale, red	15	390	
21.	**Limestone, Graham**, yellow, very shaly (1855′ B.); no fossils found	10	400	205
22.	**Shale, Upper Graham**, yellow	35	435	
23.	Sandstone, shaly	5	440	
24.	Shale, green 10′			
25.	Shale, yellow 5	**Lower Graham**	15	455
26.	**Sandstone, Bertha**, massive	5	460	
27.	**Shale, Upper Bertha**, sandy, with plant fossils (1770′ B.)	25	485	
28.	**Limestone, Bertha**, yellow (1765′ B.); contains marine fossils, a few pelecypods	5	490	90
29.	**Shale, Lower Bertha**, yellow and green (1690′ B.); contains marine fossils at base, pelecypods	75	565	
30.	Shale, dark, fissile, with plant fossils (1685′ B.)	5	570	
31.	Shale, red and variegated	40	610	
32.	**Sandstone, Bradshaw** (type locality), greenish-brown, massive at top, shaly at base, makes cliff (1615′ B.)	30	640	150

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
33.	**Shale, Bradshaw** (type locality), red.....	55	695	
34.	**Sandstone, Indian Mills** (type locality), green, fine-grained, massive, with streaks of shale (1485′ B.).....	75	770	130
35.	**Shale, Indian Mills** (type locality), green, sandy (1480′ B.); contains numerous marine fossils, pelecypods (**Sphenotus** and **Myalina**) (see **Lot 165**, collected on north side of Indian Creek 0.2 mile west of Indian Mills).....	5	775	
36.	Concealed to Indian Creek.....	10	785	

In the above section the Bradshaw Sandstone, Bradshaw Shale, Indian Mills Sandstone, and Indian Mills Shale are prominently displayed in the bluff west of, and hill road north of, Indian Mills, there being a heavy cliff of Bradshaw Sandstone visible for a mile or more up the valley of Bradshaw Creek.

The following section was measured and Fossil Lot 164 collected by the writer and these marine specimens were sent to Dr. Girty for identification. On a subsequent visit to the upper members the writer was accompanied by Paul H. Price and on this occasion plant fossils were noted in the Coney Shale and a leaf of **Bothrodendron**, which is a common genus at the type locality of this shale, was recognized:

Marie Section.

Forest Hill District, Summers County, and Red Sulphur District, Monroe County; along hill road at head of Lowell Branch of Indian Creek 0.7 mile southeast of Marie; dip northwest about 5°; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (35′)				
1.	**Sandstone, Stony Gap (Hinton** of Stevenson), massive, coarse, makes plateau in vicinity of Marie.....	35	35	35
Mauch Chunk Series—Bluefield Group (505′)				
2.	**Shale, Coney**, green, sandy, with marine fossils, including ostracods and pelecypods; numerous fragments of plant fossils, including a leaf of **Bothrodendron**.....	60	95	
3.	**Sandstone, Clayton**, massive, coarse (1985′ B.)	20	115	80
4.	**Shale, Clayton**, green, calcareous (1970′ B.); contains numerous marine fossils, pelecypods, brachiopods, and gastropods (see **Lot 164**)	15	130	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
5.	Unrecorded, with shales and sandstones...	205	335	
6.	**Sandstone, Bertha,** shaly at top, massive at base (1735′ B.).....	30	365	250
7.	**Limestone, Bertha,** very shaly.....	2	367	
8.	**Shale, Lower Bertha,** green and variegated, with marine fossils, pelecypods.....	20	387	
9.	Unrecorded, with shales and sandstones...	98	485	
10.	**Sandstone, Bradshaw,** shaly, makes cliff (1605′ B.).....	10	495	130
11.	**Shale, Bradshaw,** green and variegated, with streaks of limestone; contains marine fossils, small pelecypods.....	20	515	
12.	Unrecorded to mouth of Lowell Branch (1560′ B.).....	25	540	

MEASURED SECTIONS, PIPESTEM DISTRICT, SUMMERS COUNTY.

Pipestem District occupies the southern portion of Summers County between New and Bluestone Rivers and next to the Mercer County line. Its surface geology is wholly in the Mauch Chunk Series of the Mississippian, from the Bluestone down into the Bluefield Group. The rock structure is mainly monoclinal, rising gently southeastward toward the Abbs Valley Anticline.

The following section was originally measured by the writer, a collection of marine fossils at Lot 184 being made at this time. Another visit was paid to the region in company with Dr. Girty, at which time Lots 202 and 203 were obtained; and at a third inspection in company with Dr. David White and Paul H. Price, plant collections at Lots 242 and 243 were made. The marine fossils were studied by Dr. Girty and the plants by Dr. White:

Tallery Mountain Section.

Pipestem District, Summers County; starting at a high point on Tallery Mountain 0.6 mile east of Pleasant View School and following the highway northward to Bluestone River at True, one-fourth mile west of New River; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Bluestone Group (100′)			
1. Concealed and sandy shale from top of knob	100	100	
Mauch Chunk Series—Princeton Conglomerate (25′)			
2. **Sandstone, Princeton,** gray, massive, with quartz pebbles (2360′ B.).....	25	125	125

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Mauch Chunk Series—Hinton Group (1107′)				
3.	**Shale, Terry,** greenish-gray, sandy	24	149	
4.	**Shale, Terry** (continued), dark, sandy, with plant fossils	5	154	
5.	Shale, **Terry Limestone** horizon, sandy and ferruginous (2330′ B.); contains numerous marine fossils, chiefly brachiopods (see **Lot 184**)	1	155	
6.	**Shale, Pluto,** green, sandy	38	193	
7.	**Limestone, Pluto,** shaly (2302′ B.); contains marine fossils, crinoids, brachiopods, and gastropods	2	195	
8.	**Shale, Lower Pluto,** green, sandy, with marine fossils, brachiopods and pelecypods.	40	235	
9.	Sandstone, shaly	5	240	
10.	Shale, yellowish-green	10	250	
11.	Shale, red	50	300	
12.	**Sandstone, Falls Mills,** shaly	10	310	185
13.	Shale, red.....20′			
14.	Sandstone, shaly..... 5 } **Falls Mills Shale**	44	354	
15.	Shale, red and green.....19			
16.	**Limestone, Falls Mills,** yellow, shaly (2130′ B.)	1	355	
17.	**Shale, Upper Fivemile,** green, calcareous (2127′ B.); contains numerous marine fossils, pelecypods	3	358	
18.	**Sandstone, Tallery** (type locality), shaly (2117′ B.)	10	368	
19.	**Limestone, Tallery** (type locality), yellow, shaly	1	369	
20.	**Shale, Upper Tallery** (type locality), greenish-yellow (2110′ B.); contains plant fossils (see **Lot 241**)	6	375	
21.	**Coal, Tallery** (type locality), slaty (0′ 3″) (2110′ B.) (**Exposure No. 766 on Map VI**).	..	375	65
22.	**Shale, Lower Tallery** (type locality), sandy.	25	400	
23.	**Sandstone, Avis,** very shaly	60	460	
24.	**Shale, Upper Avis,** green, sandy	10	470	
25.	Limestone (2014′ B.); contains marine fossils, pelecypods	1	471	
26.	**Shale, Upper Avis** (continued), green (1990′ B.); contains marine fossils, pelecypods (see **Lot 203**)	24	495	
27.	**Limestone, Avis,** steel-gray, weathering yellow (1945′ B.); contains numerous marine fossils, brachiopods, etc	45	540	165
28.	Shale, red	20	560	
29.	Sandstone, shaly	5	565	
30.	Shale, red	10	575	
31.	**Sandstone, Payne Branch,** shaly	10	575	
32.	**Shale, Payne Branch,** red	65	650	
33.	**Sandstone, Hackett,** shaly, and concealed..	25	675	135
34.	Shale, red.....50′			
35.	Sandstone, shaly....10 } **Hackett Shale**....	85	760	
36.	Shale, red.....25			
37.	**Limestone, Tophet,** yellowish-red (1723′ B.)	2	762	
38.	**Shale, Upper Tophet,** red	3	765	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
39.	**Sandstone, Tophet,** shaly	25	790	
40.	**Coal, Tophet,** streak (1695′ B.) (**Exposure No. 767 on Map VI**)	..	790	115
41.	Fire clay **shale, Lower Tophet,** yellow (1692′ B.); contains plant fossils (see **Lot 242**)	3	793	
42.	**Shale, Lower Tophet** (continued), red	12	805	
43.	Sandstone, very shaly, with streaks of red shale (1645′ B.)	35	840	50
44.	**Shale, Lower Tophet** (continued), red	20	860	
45.	**Sandstone, Goodwyn,** very shaly, with red shale	25	885	
46.	**Shale, Upper Goodwyn,** red	30	915	
47.	Sandstone, shaly	20	935	
48.	Shale, green.....10′ ⎫ **Lower**			
49.	Shale, red.....20 ⎭ **Goodwyn**...	30	965	
50.	**Sandstone, Upper and Middle Bellepoint,** shaly, reddish-brown at top, green at base, makes cliff (1425′ B.)	95	1060	220
51.	**Limestone, Middle Bellepoint,** yellow	1½	1061½	
52.	**Shale, Middle Bellepoint,** variegated	7½	1069	
53.	**Shale, Middle Bellepoint** (continued), calcareous (1415′ B.); contains marine fossils, ostracods in profusion (see **Lot 202**).	1	1070	
54.	**Shale, Middle Bellepoint** (continued), variegated; contains plant fossils (see **Lot 243**); and sandstone, shaly, to Bluestone River at bridge (1375′ B.)	40	1110	
55.	Unrecorded (in boring)	59	1169	
56.	**Sandstone, Stony Gap (Hinton** of Stevenson), (in boring), (1253′ L.)	63	1232	

In the above section Nos. 55 and 56 are obtained from Bore Hole No. 14A of the West Virginia Power Company, located on the north side of Bluestone River just north of the foot of the measured portion, being one of a vast number of shallow tests made by this company in search of a dam site during the season of 1924. The identification of the sandstone in this boring was made by Dr. I. C. White who paid a visit to the locality during the progress of the tests. The bottom of the ledge was not reached in this boring but almost its full thickness must be represented since it is only 45 feet at Hinton and not more than 70 feet at any of the other outcrops and most of the borings of the region.

A remarkable feature of the measured section is the great thickness of sandstone at the Upper and Middle Bellepoint horizons where the two appear to have coalesced into one vast unit 95 feet thick. Farther up the mountain along the

new State road where all the observations were made the Mauch Chunk strata are revealed in great detail in the deep cuts, the region being selected as the type locality of several members.

SUMMARY OF MEASURED SECTIONS.

For convenient reference the thickness of the stratified rocks of Mercer, Monroe, and Summers Counties, as determined by the measured sections in this Chapter, is compiled in the following table, showing not only the thicknesses of the various groups and series but also the totals for the different periods down to the lowest depths to which there are exposures. A line of dots (.....) under a group or series indicates that it was not exposed, or in some cases not examined, where the section was measured. A question mark (?) indicates that the group or series was present and was examined but could not be differentiated from the overlying or underlying formation. A plus mark (+) indicates that only a portion of the full group, series, or period is included in the section. In some cases a section shows the thickness of a group or series too great or too small, owing to the dip of the measures where it was made, a reduction to true vertical measurement not being always practicable. Many sections, however, measured along steeply dipping rocks, were corrected for dip and show approximately true intervals. An explanation accompanies each section, where published in the text, detailing the conditions under which it was made, and this should always be consulted before assuming that the tabulated thicknesses are final:

Table Showing Thickness of Stratified Rocks in Measured Sections of Mercer, Monroe, and Summers Counties.

PLACE MEASURED	PENNSYLVANIAN			MISSISSIPPIAN								
	POTTSVILLE			MAUCH CHUNK								
	New River	Pocahontas	TOTAL	Bluestone	Princeton	Hinton	Bluefield	TOTAL	Greenbrier	Maccrady	Pocono	TOTAL
Alderson	.....	90+	90+	663	35	849	1202	2749	30+	.....	.....	2779
Athens	.....	.....	.....	.....	.....	305+	.....	305+	.....	.....	.....	305+
Bellepoint	.....	.....	.....	.....	60	1085	20+	1165+	.....	.....	.....	1165+
Bertha	.....	.....	.....	.....	25+	1050	405+	1480+	.....	.....	.....	1480+
Bickett Knob	.....	.....	.....	.....	.....	.....	410+	410+	1040	290	40+	1780+
Blake	.....	.....	.....	.....	.....	.....	.....	.....	.....	10+	70	80+
Bluefield	.....	.....	.....	.....	.....	.....	.....	.....	.....	265	390	655+
Bluefield Fair-Grounds	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Brick Church	.....	.....	.....	.....	.....	.....	.....	.....	.....	195	276	471+
Caldwell	.....	.....	.....	.....	.....	.....	.....	.....	.....	75+	420	495+
Elmhurst	.....	.....	.....	.....	.....	.....	330+	330+	1065+	.....	.....	1395+
Falls Mills	.....	.....	.....	.....	30	592+	.....	622+	.....	.....	.....	622+
Gap Mills	.....	.....	.....	.....	.....	.....	.....	.....	.....	418	868	1286+
Glenlyn	.....	.....	.....	.....	.....	.....	510+	510+	.....	.....	.....	510+
Glenray	.....	.....	.....	.....	.....	175	680+	855+	.....	.....	.....	855+
Graham	.....	.....	.....	.....	.....	.....	656+	656+	.....	.....	.....	656+
Green Sulphur Springs	.....	120+	120+	435	20	?	?	2220	695	25	600	3540
Hanging Rock	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hinton	.....	90+	90+	500	40	1055	75+	1670+	.....	.....	.....	1670+
Hokes Mill	.....	.....	.....	.....	.....	.....	.....	.....	140+	175	145+	460+
Indian Mills	.....	.....	.....	.....	.....	195+	590+	785+	.....	.....	.....	785+
Lindside	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	511	511+
Lurich	.....	.....	.....	.....	.....	.....	837+	837+	1721	?	298	2856+
Maple Grove School	.....	.....	.....	.....	.....	.....	.....	.....	115+	10+	.....	125+
Marie	.....	.....	.....	.....	.....	35+	505+	540+	.....	.....	.....	540+
Narrows	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Nemours	.....	.....	.....	.....	.....	.....	217+	217+	.....	.....	.....	217+
New Richmond	55	490	545+	405	60	990	20+	1475+	.....	.....	.....	1475+
Patton	.....	.....	.....	.....	.....	.....	.....	.....	410+	.....	.....	410+
Pence Springs	.....	.....	.....	.....	35	835	480+	1350+	.....	.....	.....	1350+
Pigeon Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	?	?·
Pride	.....	.....	.....	558+	25	235+	.....	818+	.....	.....	.....	818+
Ramp	.....	35+	35+	470	25	805+	.....	1300+	.....	.....	.....	1300+
Red Sulphur Springs	.....	.....	.....	.....	.....	15+	557+	572+	.....	.....	.....	572+
Rich Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ripplemead	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Roxalia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	?	?
Snidows Ferry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Spider Den School	.....	.....	.....	.....	.....	.....	.....	.....	65+	115	320+	500+
Stony Gap	.....	.....	.....	620+	40	1330	1248	3238+	1795	132	318	5483+
Talcott	.....	.....	.....	.....	.....	20+	215+	235+	.....	.....	.....	235+
Tallery Mountain	.....	.....	.....	100+	25	1107+	.....	1232+	.....	.....	.....	1232+
Warford	.....	.....	.....	.....	35+	970	1350	2355+	1415	127	538+	4435+
Waugh Siding	.....	.....	.....	.....	.....	.....	220+	220+	175+	.....	.....	395+
Wikel	.....	.....	.....	.....	.....	.....	529+	529+	.....	.....	.....	529+

Table Showing Thickness of Stratified Rocks in Measured Sections of Mercer, Monroe, and Summers Counties (Continued).

PLACE MEASURED	DEVONIAN							
	Chemung	Portage	Genesee	Hamilton	Marcellus	Oriskany	Helderberg	TOTAL
Alderson	.....	.....	.....	.....	.....	.....	.....	.....
Athens	.....	.....	.....	.....	.....	.....	.....	.....
Bellepoint	.....	.....	.....	.....	.....	.....	.....	.....
Bertha	.....	.....	.....	.....	.....	.....	.....	.....
Bickett Knob	.....	.....	.....	.....	.....	.....	.....	.....
Blake	542+	.....	.....	.....	.....	.....	.....	542+
Bluefield	?	?	.....	.....	50+	.....	.....	1000+
Bluefield Fair-Grounds	.....	.....	.....	.....	.....	.....	.....	.....
Brick Church	.....	.....	.....	.....	.....	.....	.....	.....
Caldwell	425+	.....	.....	.....	.....	.....	.....	425+
Elmhurst	.....	.....	.....	.....	.....	.....	.....	.....
Falls Mills	.....	.....	.....	.....	.....	.....	.....	.....
Gap Mills	1537	2450	.....	635	.....	140	72	4834
Glenlyn	.....	.....	.....	.....	.....	.....	.....	.....
Glenray	.....	.....	.....	.....	.....	.....	.....	.....
Graham	.....	.....	.....	.....	.....	.....	.....	.....
Green Sulphur Springs	775+	.....	.....	.....	.....	.....	.....	775+
Hanging Rock	.....	.....	.....	.....	.....	.....	.....	.....
Hinton	.....	.....	.....	.....	.....	.....	.....	.....
Hokes Mill	.....	.....	.....	.....	.....	.....	.....	.....
Indian Mills	.....	.....	.....	.....	.....	.....	.....	.....
Lindside	.....	.....	.....	.....	.....	.....	.....	.....
Lurich	95	170+	.....	.....	.....	.....	.....	265+
Maple Grove School	.....	.....	.....	.....	.....	.....	.....	.....
Marie	.....	.....	.....	.....	.....	.....	.....	.....
Narrows	.....	.....	.....	.....	.....	.....	.....	.....
Nemours	.....	.....	.....	.....	.....	.....	.....	.....
New Richmond	.....	.....	.....	.....	.....	.....	.....	.....
Patton	.....	.....	.....	.....	.....	.....	.....	.....
Pence Springs	.....	.....	.....	.....	.....	.....	.....	.....
Pigeon Creek	?	803	.....	.....	90+	.....	.....	?
Pride	.....	.....	.....	.....	.....	.....	.....	.....
Ramp	.....	.....	.....	.....	.....	.....	.....	.....
Red Sulphur Springs	.....	.....	.....	.....	.....	.....	.....	.....
Rih Creek	.....	.....	.....	.....	.....	.....	.....	.....
Ripplemead	.....	.....	.....	.....	.....	.....	.....	.....
Roxalia	?	.....	.....	.....	.....	.....	.....	?
Snidows Ferry	.....	.....	.....	.....	.....	.....	.....	.....
Spider Den School	.....	.....	.....	.....	.....	.....	.....	.....
Stony Gap	110+	.....	.....	.....	.....	.....	.....	110+
Talcott	.....	.....	.....	.....	.....	.....	.....	.....
Tallery Mountain	.....	.....	.....	.....	.....	.....	.....	.....
Warford	.....	.....	.....	.....	.....	.....	.....	.....
Waugh Siding	.....	.....	.....	.....	.....	.....	.....	.....
Wikel	.....	.....	.....	.....	.....	.....	.....	.....

Table Showing Thickness of Stratified Rocks in Measured Sections of Mercer, Monroe, and Summers Counties (Concluded).

PLACE MEASURED	SILURIAN					ORDOVICIAN								TOTAL SECTION
						MARTINSBURG								
	Clinton	White Medina	Red Medina	Gray Medina	TOTAL	Lower Maysville	Eden	Trenton	TOTAL	Moccasin	Stones River	Beekmantown	TOTAL	
Alderson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2869
Athens	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	305
Bellepoint	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1165
Bertha	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1480
Bickett Knob	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1780
Blake	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	622
Bluefield	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1655
Bluefield Fair Grounds	540+	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	905
Brick Church	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	471
Caldwell	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	920
Elmhurst	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1395
Falls Mills	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	622
Gap Mills	358	110	330+	.....	798+	.....	.....	.....	.....	.....	.....	.....	.....	6918
Glenlyn	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	510
Glenray	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	855
Graham	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	656
Green Sulphur Springs	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4435
Hanging Rock	.....	60+	360	.....	420+	?	?	322	1345	396	640	2400+	4831+	5251
Hinton	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1760
Hokes Mill	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	460
Indian Mills	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	785
Lindside	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	511
Lurich	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	487	950+	1437+	4558
Maple Grove School	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	125
Marie	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	540
Narrows	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	390	3687+	4077+	4077
Nemours	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	217
New Richmond	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2020
Patton	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	410
Pence Springs	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1350
Pigeon Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1551
Pride	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	818
Ramp	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1335
Red Sulphur Springs	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	572
Rich Creek	445+	120	390	2	957+	362	455	731	1548	419	618	910+	3495+	4452
Ripplemead	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	235+	670+	905+	905
Roxalia	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	545
Snidows Ferry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	305+	590+	895+	895
Spider Den School	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500
Stony Gap	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5593
Taleott	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	235
Tallery Mountain	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1232
Warford	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4435
Waugh Siding	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	395
Wikel	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	529

CHAPTER VI.

STRATIGRAPHY--POTTSVILLE SERIES.

GENERAL ACCOUNT AND SECTION, POTTSVILLE SERIES.

The Pottsville Series of the Pennsylvanian, coming at the base of this period and lying just over the red shales of the Mauch Chunk Series, comprises the youngest stratified beds in the three counties. In adjacent counties to the westward and northward the Pottsville has a maximum thickness of approximately 3,850 feet, being composed of the three following groups in descending stratigraphic order, as long ago subdivided by Dr. I. C. White:

Kanawha Group	2,100 feet.
New River Group	1,030 feet.
Pocahontas Group	720 feet.

On account of the southeastward rise of the rocks there now remain in the three counties under study about 565 feet of the New River Group and the Pocahontas Group which measures about 465 feet, the entire Kanawha and about half of the New River being eroded from the summits.

The portion of the series remaining in these counties consists of gray, coarse, massive or current-bedded sandstones, some ledges of which contain angular or slightly rounded quartz pebbles, sandy or carbonaceous shales usually carrying abundant plant fossils and occasional fresh- or brackish-

[1]Ray V. Hennen, Fayette Report, W. Va. Geol. Survey, pp. 100-111; 1919. C. E. Krebs, Raleigh County and Western Portions of Mercer and Summers Counties Report, W. Va. Geol. Survey, pp. 325-334; 1916.

water faunas, and coal seams, several of which are of commercial thickness and very pure. Bedded limestones are entirely unknown, there being a few concretionary lentils in some of the shales. True fire clays, which occur in some abundance in the Kanawha Group farther northeast in the State, are unknown in the New River and Pocahontas Groups.

The following general section, taken almost entirely from former publications of the Survey[1], but slightly revised to conform to the known strata of Mercer and Summers Counties, illustrates the character of the series in this area:

General Section of the Pottsville Series for Mercer and Summers Counties.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
New River Group (565'+)				
1.	**Sandstone, Lower Guyandot,** grayish-white, massive or current-bedded, medium-grained, lenticular; forms cliffs in Mercer County	20 to 50	50	
2.	**Shale, Hartridge,** dark, with plant fossils, and often carrying a fresh- or brackish-water fauna in Fayette and other counties	0 to 7	57	
3.	**Coal, Sewell,** generally double-bedded, soft, columnar, mined commercially in Fayette, Raleigh, McDowell, and other counties; noted in Mercer County as	1 to 3	60	60
4.	Shale, gray, sandy, lenticular	40 to 5	65	
5.	**Sandstone, Welch,** grayish-white, massive to current-bedded, lenticular	0 to 35	100	
6.	Shale, dark, argillaceous, lenticular	0 to 8	108	
7.	**Coal, Welch,** multiple-bedded, soft, columnar, noted in Mercer County as	1 to 2	110	50
8.	Shale, gray, sandy	0 to 15	125	
9.	**Sandstone, Upper Raleigh,** grayish-white or brown, heavy- to current-bedded; makes cliffs	50 to 85	210	
10.	**Coal, Little Raleigh "A",** streak	.. .. ..	210	100
11.	Shale, sandy, lenticular	0 to 15	225	
12.	**Coal, Little Raleigh,** streak	.. .. ..	225	15
13.	Shale, sandy, lenticular	15 to 5	230	
14.	**Sandstone, Lower Raleigh,** massive or current-bedded, lenticular; makes cliffs	25 to 65	295	
15.	Shale, argillaceous, lenticular	0 to 17	312	
16.	**Coal, Beckley,** multiple-bedded, soft, columnar; noted in Mercer County as	1 to 3	315	90

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
17.	**Sandstone, Quinnimont,** lenticular....	0 to 75	390	
18.	**Shale, Quinnimont,** dark-gray, siliceous or argillaceous, laminated, lenticular	0 to 47	437	
19.	**Coal, Fire Creek, "Quinnimont,"** multiple-bedded, soft, columnar....	1 to 3	440	125
20.	Shale, sandy, with sandstone layers..	10 to 25	465	
21.	**Coal, Little Fire Creek,** streak.....	.. .. ..	465	25
22.	**Sandstone, Pineville,** massive or current-bedded; forms cliffs.....	45 to 60	525	
23.	Shale, sandy	0 to 8	533	
24.	**Coal, No. 9 Pocahontas,** multiple-bedded, soft, columnar	0 to 2	535	70
25.	Shale and sandstone, mixed.....	0 to 28	563	
26.	**Coal, No. 8 Pocahontas,** impure, soft, columnar	0 to 2	565	30
Pocahontas Group (465′)				
27.	**Sandstone, Flattop Mountain,** bluish-gray or brown, massive, or current-bedded, medium-grained, micaceous; caps ridge summit of Flattop Mountain at Coaldale, Mercer County....	20 to 50	615	
28.	**Shale, Rift,** dark-gray, with argillaceous and siliceous layers, cropping in Big Creek at Rift, McDowell County	30 to 10	625	
29.	**Coal, No. 7 Pocahontas,** streak.....	.. .. ..	625	60
30.	Shale, gray, sandy.....	0 to 5	630	
31.	**Sandstone, Pierpont,** bluish-gray or light-gray, massive or current-bedded, medium-grained, hard, micaceous, sometimes pebbly.....	39 to 40	670	
32.	Shale, sandy, alternating with sandstone	0 to 21	691	
33.	**Shale, Royal,** buff, sandy, with fresh- or brackish-water fauna in Raleigh, Fayette, and Mercer Counties.....	0 to 5	696	
34.	**Coal, No. 6 Pocahontas,** multiple-bedded, soft, columnar; mined commercially in Mercer County and in Hump Mountain, Summers County.	2 to 4	700	75
35.	Shale, sandy	0 to 5	705	
36.	**Sandstone, Eckman,** buff or bluish-gray, massive or current-bedded, medium-grained; often cuts out the No. 5 and No. 4 Pocahontas Coals..	30 to 45	750	
37.	**Coal, No. 5 Pocahontas,** streak.....	.. .. ..	750	50
38.	Shale, sandstone, and dark shale, with abundant plant fossils.....	0 to 17	767	
39.	**Coal, No. 4 Pocahontas**.....	0 to 3	770	20
40.	Shale, sandy	0 to 5	775	
41.	**Sandstone, Upper Pocahontas,** massive or heavy-bedded, medium-grained or coarse; quarried at Pocahontas, Virginia	25 to 55	830	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
42.	Shale, dark, with abundant plant fossils and with fresh- or brackish-water fauna reported on Piney Creek, Raleigh County.....	0 to 5	835	
43.	**Coal, No. 3 Pocahontas,** multiple-bedded, soft, columnar; mined extensively in Mercer County.....	0 to 10	845	75
44.	Shale, gray, sandy.....	0 to 10	855	
45.	**Sandstone, Lower Pocahontas,** generally massive, medium-grained.....	0 to 40	895	
46.	Shale, gray, sandy.....	0 to 8	903	
47.	**Coal, No. 2 Pocahontas,** multiple-bedded, soft, columnar.....	0 to 2	905	60
48.	Shale, gray	0 to 5	910	
49.	**Sandstone, Vivian,** bluish-gray, massive, medium-grained, lenticular; quarried at East Vivian, McDowell County	0 to 30	940	
50.	**Coal, No. 1 Pocahontas,** streak.....	.. .. ..	940	35
51.	Shale, sandy	0 to 10	950	
52.	**Sandstone, Keystone,** buff, massive, coarse, pebbly; makes cliffs at Keystone, McDowell County.....	0 to 30	980	
53.	**Coal, Keystone,** streak.....	.. .. ..	989	40
54.	Shale and sandstone.....	0 to 15	995	
55.	**Shale, North Fork,** black, with lenses of iron ore; carries plant fossils on Elk Knob, Summers County (see **Lot 226**), and fresh- or brackish-water fanua at same locality, abundant ostracods and also pelecypods (**Naiadites**) (see **Lot 226A**).....	0 to 20	1015	
56.	Shale, sandy, lenticular.....	0 to 15	1030	50
57.	Red shale of **Mauch Chunk Series**...	.. ..	....	..

A study of the above section shows that from a lithologic standpoint it contains approximately 64 per cent. of sandstone, 33 per cent. of shaly material, and 3 per cent. of coal.

SUBDIVISIONS, POTTSVILLE SERIES.

The three main groups into which the Pottsville has been divided by Dr. I. C. White have already been named on a preceding page of this Chapter and the minor subdivisions, or members, as believed or known to occur in Mercer and Summers Counties, together with their sequence, are indicated in the General Section just above. Several of these more important members have now been traced entirely across West Virginia, Maryland, and Pennsylvania, in all three of which States the same nomenclature has been gen-

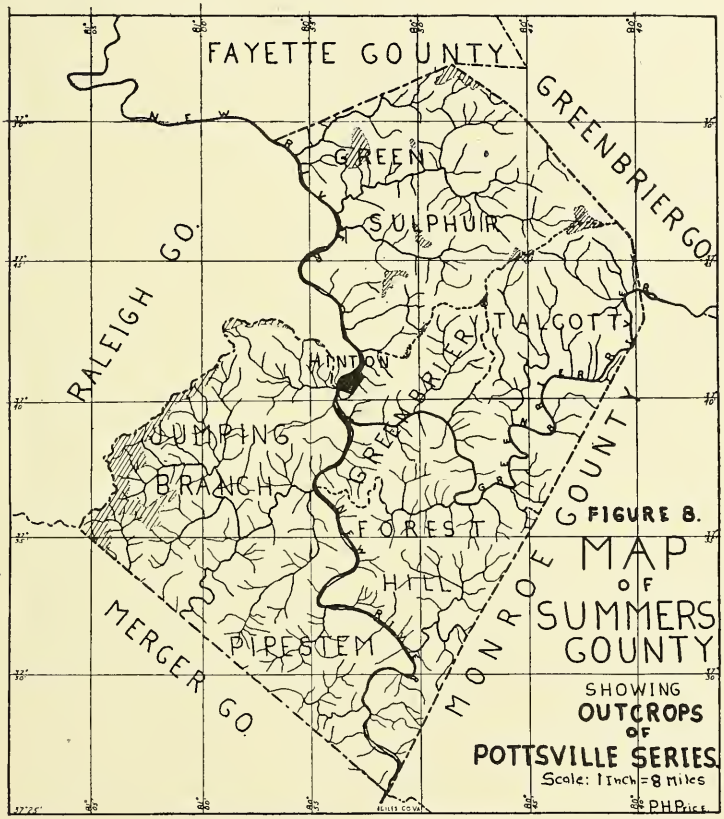
erally employed. Farther south in the Appalachian region different groupings and different names of members have been used in Virginia, Kentucky, Tennessee, and Alabama so that it is difficult to know the extent of any single group or member but there is little doubt that various horizons of the southern West Virginia phase continue through several of these States. The minor subdivisions will be discussed under a subsequent heading.

AREAL EXTENT, POTTSVILLE SERIES.

The outcrop of the series is now confined to the northwestern edge of Mercer County, including portions of Rock and Jumping Branch Districts, and to the western and northern parts of Summers County, including the western edge of Jumping Branch District and a few high summits in Green Sulphur, Hinton, Greenbrier, and Talcott Districts. In Monroe County the series does not occur.

Figures 7 and 8, prepared by Mr. Price, show at a glance

the Pottsville outcrops of Mercer and Summers Counties, respectively. Their more detailed occurrence may also be noted on the separate Maps II and VI of the Atlas which accompanies this Report.



CONTACTS, POTTSVILLE SERIES.

The contact of the New River Group of the Pottsville with the underlying Pocahontas is based largely on certain differences in the nature of the coals and on the changes in the fossil plants, there being little evidence of unconformity. This division plane has been somewhat arbitrarily placed at the base of the No. 8 Pocahontas Coal where, for the sake of convenience, it remains.

At the base of the Pocahontas Group and of the Pottsville Series, however, there is a very striking unconformity that is apparently as wide-spread as the areal extent of the series in the whole Appalachian region. Here the gray, coarse, massive, and often pebbly sandstones of the Pennsylvanian, with their associated coals and shales which abound in fossil plants of Upper Carboniferous aspects, rest upon the red and green shales and frequently greenish sandstones of the Mauch Chunk Series of the Mississippian in which there are frequent marine faunas and in which the plants are of a distinctly earlier type. In the Mauch Chunk also, there is a total absence of coals of commercial thickness and purity, there being only occasional thin or impure streaks. The two series have now been studied so much in the Appalachian region that there is small likelihood that sediments will ever be found to bridge this hiatus and it is not certain that such sediments ever existed, since it appears probable that a long epoch of aerial exposure may have occurred at the end of Mauch Chunk time when the upper beds lay quiescent until Pottsville sedimentation suddenly began. The varying thickness of the Mauch Chunk along well-defined lines of strike, however, is conclusive evidence that much erosion occurred in various regions. The upper strata of the Mauch Chunk in Mercer County are among the youngest known to exist in this series and the lower beds of the Pottsville in this and McDowell County are likewise of very early Pottsville age so that scarcely any better region could be found in which to study this very interesting contact.

FOSSIL LIFE, POTTSVILLE SERIES.

In the Pottsville Series fossil plant life is abundant and well preserved both in the shales above and below the coals and in the bases of the sandstones. These forms have been widely studied in southern West Virgina by many authorities[2], and call for no further comment here. Only one small collection (Lot 226) of plants from this series was made for

[2]See Vol. V(A), Part II, W. Va. Geol. Survey, 1913, for discussion of many of these plants by David White.

the present Report, this being in the base of the Keystone Sandstone, as will be later described.

In sharp contrast to the abundance of plant life in the Pottsville is the very scanty occurrence of marine or even brackish- or fresh-water faunas. There are a few zones of marine fossils in the Kanawha Group in other counties but in the New River there are only a few known occurrences of marine types and in the Pocahontas there are apparently none. In both of these latter groups, however, there are a few horizons where fresh- or brackish-water forms have been observed, those members which may be expected to hold them in Mercer and Summers Counties being named in the General Section of the Pottsville at the beginning of this Chapter. In the much more restricted area of Pottsville which was studied in detail by the writer for this Report only one occurrence of a fresh- or brackish-water fauna (Lot 226A) was observed. An account of this locality will be found on a later page.

CORRELATION, POTTSVILLE SERIES.

The Pottsville Series forms such a little part of the subject of this Report that a review of its widely extended beds is hardly of present interest. In a recent Report of the Survey[3], however, the writer has briefly expressed his views relative to the various members of the series which extend entirely across West Virginia and into Maryland and Pennsylvania. In the southern Appalachian States the series has been studied locally by many competent observers but, as previously stated, separate nomenclatures have been employed and apparently little systematic attempt toward tracing groups and members into extra-territorial areas has been made, except that the fossil plants have been broadly studied by Dr. David White of the United States Geological Survey. From observations made in conjunction with other studies at various times and localities the writer believes that many of the Pottsville members in southern West Virginia may be definitely traced across

[3]David B. Reger, Mineral and Grant Report, W. Va. Geol. Survey, pp. 249-253; 1924.

Virginia, Kentucky, and Tennessee and perhaps farther south, but the problem will require long and laborious work in the field even after all available plant and marine fossils shall have been definitely assigned to the local stratigraphic columns, and until such a study has been accomplished hasty impressions may well be reserved.

DESCRIPTION OF MEMBERS, NEW RIVER GROUP OF POTTSVILLE SERIES.

Apparently the highest outcropping member of the New River Group in either Mercer of Summers County is the Lower Guyandot Sandstone, coming a few feet above the Sewell Coal. This sandstone and all the other members of the group in the two counties have been studied and described by Krebs[4] in a former Report of the Survey. Their description is now called for only insofar as these members may occur in the territory assigned to the present Report, as detailed in Chapter I.

PINEVILLE SANDSTONE.

The **Pineville Sandstone** of Hennen[5], belonging just below the Little Fire Creek Coal and only a comparatively few feet below the main Fire Creek Coal, is the only member of the New River Group that appears now to remain in the tops of the mountains in the territory of this Report. This sandstone was observed only in Hump Mountain in Green Sulphur District, Summers County, where, as recorded in the New Richmond Section in Chapter V, it is white, massive, coarse, medium-hard, and 55 feet thick and forms the top of the mountain. Its presence at this locality is in harmony with the statement of Hennen[6] that it is a prominent ledge in southern Fayette County next to the Summers County line. A sample of this sandstone was collected by Hennen in Green-

[4]C. E. Krebs, Raleigh County and Western Portions of Mercer and Summers Counties Report, W. Va. Geol. Survey, pp. 354-366; 1916.

[5]Ray V. Hennen, Wyoming-McDowell Report, W. Va. Geol. Survey, pp. 211-212; 1915.

[6]Ray V. Hennen, Fayette Report, W. Va. Geol. Survey, pp. 321-322; 1919.

brier County on Meadow River near the mouth of Burdette Creek, and showed a silica content of 98.93 per cent., as published on page 912 of the Fayette County Report. If the silica content is as high at the Hump Mountain exposure as in the above analysis, as would appear probable from its appearance, it should make good glass-sand.

The **No. 9 Pocahontas** and **No. 8 Pocahontas Coals,** which together with shales and thin sandstones occupy the interval between the Pineville Sandstone and the top of the Pocahontas Group in the western part of Mercer and in McDowell County, were not observed in northern Summers. According to Hennen these two coals are also absent from the measures in Fayette County. Their disappearance in this direction is in harmony with the known northeastward thinning of the Pottsville Series.

DESCRIPTION OF MEMBERS, POCAHONTAS GROUP OF POTTSVILLE SERIES.

The occurrence and general aspects of the various members of the Pocahontas Group in Rock and Jumping Branch Districts, Mercer County, and Jumping Brnach District, Summers County, have already been discussed by Krebs in the Raleigh Report of the Survey. In northern Summers County the whole group is present in one high knob and portions of it are preserved at other localities, although the group has thinned to slightly less than 500 feet as compared to its apparent maximum of 720 feet in McDowell County. The members which are known to occur in northern Summers east of New River will now be discussed.

FLATTOP MOUNTAIN SANDSTONE.

The **Flattop Mountain Sandstone** of White[7], as first named by him and as later more elaborately defined by Hennen[8], is the uppermost member of the Pocahontas Group, its type locality being in Flattop Mountain along the western

[7]I. C. White, Vol. II(A), W. Va. Geol. Survey, pp. 13-14; 1908.
[8]Ray V. Hennen, Wyoming-McDowell Report, W. Va. Geol. Survey, pp. 216-217; 1915.

edge of Mercer County. It is described as bluish-gray or brown, massive or current-bedded, medium-grained, micaceous, and 20 to 50 feet thick. In northern Summers County it should occur near the top of Hump Mountain, Green Sulphur District, but at that locality its horizon appears to be concealed in 65 feet of covered strata, as recorded in No. 2 of the New Richmond Section in Chapter V. In the extreme northern end of the county, at the corner with Fayette and Greenbrier, it is possible that a fragment of this sandstone may be preserved in the top of Wallowhole Mountain but no special investigation was made to determine this point.

The **Rift Shale,** belonging just below the Flattop Mountain Sandstone and the **No. 7 Pocahontas Coal,** lying just below the Rift Shale, were not observed at outcrop in northern Summers, their horizons being concealed in Hump Mountain where they might be expected.

PIERPONT SANDSTONE.

The **Pierpont Sandstone** of Hennen[9], belonging a few feet below the No. 7 Pocahontas Coal, and described as bluish-gray or light-gray, massive or current-bedded, medium-grained, hard, micaceous, sometimes pebbly, and 40 to 60 feet thick, was observed in the upper part of Hump Mountain in northern Summers County, being there gray, massive, and pebbly with a thickness of 80 feet and with a basal elevation of 3,100′ B., as recorded in the New Richmond Section of Chapter V. On the north side of this mountain it is visible at the mine of the Hump Mountain Smokeless Coal Company **(No. 746 on Map VI)**, being 50 feet thick and pebbly, and almost directly overlying the No. 6 Pocahontas Coal. It should also occur in the tops of Wallowhole and Irish Mountains.

ROYAL SHALE.

The **Royal Shale** of Krebs[10], belonging between the Pierpont Sandstone and No. 6 Pocahontas Coal, and described as

[9]Ibid., pp. 218-219.

[10]C. E. Krebs, Raleigh County and Western Portions of Mercer and Summers Counties Report, W. Va. Geol. Survey, pp. 366-367; 1916.

buff and sandy, with a fresh- or brackish-water fauna, was not observed in northern Summers County, and its presence there is problematical since there is only a six-inch stratum of bone between the sandstone and coal at the mine of the Hump Mountain Smokeless Coal Company on the northern side of Hump Mountain. Wallowhole and Irish Mountains should both be high enough to hold its horizon. In northern Fayette County it is reported by Hennen as occurring in the roof shales of certain openings in the No. 6 Pocahontas Coal.

NO. 6 POCAHONTAS COAL.

The **No. 6 Pocahontas Coal** of White[11], belonging just below the Royal Shale and only a few feet below the Pierpont Sandstone, is present in a few knobs in northern Summers, being protected from erosion by the great overlying ledge. In this region and in the southern edge of Fayette County where more prospects are available, it is soft, columnar, and usually though not always multiple-bedded. It is mined commercially on the northern side of Hump Mountain. Its outcrop is shown on Maps II and VI; and in Chapter XIII, under the subject of "Commercial Coal", its extent, chemical character, and tonnage, together with available bed-sections, will be discussed.

The **Eckman Sandstone, No. 5 Pocahontas Coal,** and **No. 4 Pocahontas Coal,** described as occupying the interval between the No. 6 Pocahontas Coal and the Upper Pocahontas Sandstone, in the order named, were not observed in northern Summers County, although in the upper part of Hump Mountain there is sufficient interval in No. 5 of the New Richmond Section to contain them and they would also belong in Wallowhole and Irish Mountains. Farther southwest they are noted by Krebs as occurring in the western parts of Mercer and Summers Counties, and the statement is made that the No. 4 Pocahontas at some points is thick enough for mining.

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[11]I. C. White, Vol. II(A), W. Va. Geol. Survey, pp. 103-104; 1908.

UPPER POCAHONTAS SANDSTONE.

The **Upper Pocahontas Sandstone** of Hennen[12], belonging a few feet below the No. 4 Pocahontas Coal and a few feet above the No. 3 Pocahontas, and described as massive or heavy-bedded, medium-grained or coarse, and 25 to 55 feet thick, was noted in Hump Mountain in northern Summers County, as recorded in the New Richmond Section in Chapter V. Its exposure is quite imperfect, however, so that its thickness and other characteristics are uncertain. It should also occur in Wallowhole and Irish Mountains.

NO. 3 POCAHONTAS COAL.

The **No. 3 Pocahontas Coal** of Hotchkiss, Lathrop, and White[13], having its type locality at Pocahontas, Virginia, is the principal seam that is being mined at many large plants in western Mercer County. As described by Krebs at numerous mines it is multiple-bedded, soft, and columnar with a thickness that varies from 3 to 10 feet, although his General Section of the Pottsville Series indicates a range in thickness from 0 to 15 feet.

In Hump Mountain, northern Summers County, this coal is 4 feet 11 inches thick, with partings, but has not been mined. Its outcrop is shown on Maps II and VI and in Chapter XIII, under the subject of "Commercial Coal", its extent, chemical character, and tonnage, together with available bed-sections, will be discussed.

LOWER POCAHONTAS SANDSTONE.

The **Lower Pocahontas Sandstone** of Hennen[14], occupying most of the interval between the No. 3 Pocahontas and No. 2 Pocahontas Coals, and described as generally massive, medium-grained, and 0 to 50 feet thick, but as sometimes carry-

[12]Ray V. Hennen, Wyoming-McDowell Report, W. Va. Geol. Survey, pp. 224-225; 1915.

[13]W. A. Lathrop, "The Virginias", June, 1884, p. 97; and I. C. White, Bull. 65, U. S. Geol. Survey, pp. 203-204, 1891; Vol. II, pp. 689-690, 1903; and Vol. II(A), pp. 103-104, 1908; W. Va. Geol. Survey.

[14]Ray V. Hennen, Wyoming-McDowell Report, W. Va. Geol. Survey, pp. 228-230; 1915.

ing a thin coal within its mass when it becomes shaly, appears to be present in certain high knobs in northern Summers County. In Hump Mountain it is 30 feet thick, gray and massive, coming 25 feet below a prospect in the No. 3 Pocahontas Coal, as recorded in the New Richmond Section in Chapter V, and in the Alderson Section of the same Chapter, where it forms the extreme top of Keeney Knob in Talcott District, it is noted as 22 feet thick and gray in color. It should also occur in a few of the other high knobs in northern Summers.

NO. 2 POCAHONTAS COAL.

The **No. 2 Pocahontas Coal** of Lathrop and White, as named in the publications of these authors previously cited, and belonging beneath the Lower Pocahontas Sandstone, has been described in various Reports of the Survey as multiple-bedded, soft, and columnar. In the western portion of Mercer County several openings have been noted by Krebs in the Raleigh Report, their thickness varying from 1 to 3½ feet, and the statement is made that the seam is of minable thickness and purity in Rock District. Northward it appears to thin out and is not regarded as of value in the western portion of Summers County. In the northern region of this County it was not observed at any exposure and in the adjoining portion of Fayette County it is described by Hennen as having little value. In Chapter XIII, under the subject of "Commercial Coal", will be found the tonnage estimates of Krebs for Rock District, Mercer County.

The **Vivian Sandstone,** belonging a few feet under the 2 Pocahontas Coals, and described as generally massive, meing below the Vivian Sandstone from which it is sometimes separated by a shale bed, were not noted in northern Summers County.

KEYSTONE SANDSTONE.

The **Keystone Sandstone** of Hennen[15], belonging at a

[15]Ibid., pp. 237-238.

short interval below the No. 1 Pocahontas Coal, from which it is sometimes separated by the lenticular **Landgraff Sandstone** and **Landgraff Coal,** appears to be the next member of the group found in the descending succession in northern Summers County. This sandstone is buff, massive, coarse, and usually pebbly, with a thickness that sometimes reaches 30 to 40 feet. In Chapter V it is recorded in the Green Sulphur Springs Section as 20 feet thick, buff, massive, and pebbly; in that for New Richmond as brown, coarse, and micaceous, its thickness being uncertain; in that for Hinton as gray, massive, and coarse, making a 55-foot cliff; and in that for Alderson as 23 feet thick and buff in color. In the top of Elk Knob of Keeney Mountain it is a gray, coarse, and massive cliff, with a few pebbles and having plant fossils at the base, **Lot 226** having been collected at this locality, as detailed under the description of **Coal Prospect No. 752** on a following page. This persistent and very durable ledge has been largely responsible for the preservation of the few remnants of the Pocahontas Group in this region since it has formed a protecting shoulder at the top of the Mauch Chunk red beds just over which it frequently lies when the Keystone Coal and North Fork Shale have locally disappeared. The general characteristics of this sandstone are such that it would make excellent building stone but its removal to markets from its high outcrops in the mountains would be costly.

KEYSTONE COAL.

The **Keystone Coal** of Hennen[16], belonging a few feet below the Keystone Sandstone, is a thin and lenticular seam that was observed at a few localities in northern Summers County, being too thin for mining at any known point and frequently absent.

At **Exposure No. 751 on Map VI** on Hump Mountain two miles northward from New Richmond, Green Sulphur District, the blossom of this coal is visible at elevation 2,880′ B., as recorded in the New Richmond Section, page 242.

[16]Ibid., p. 238.

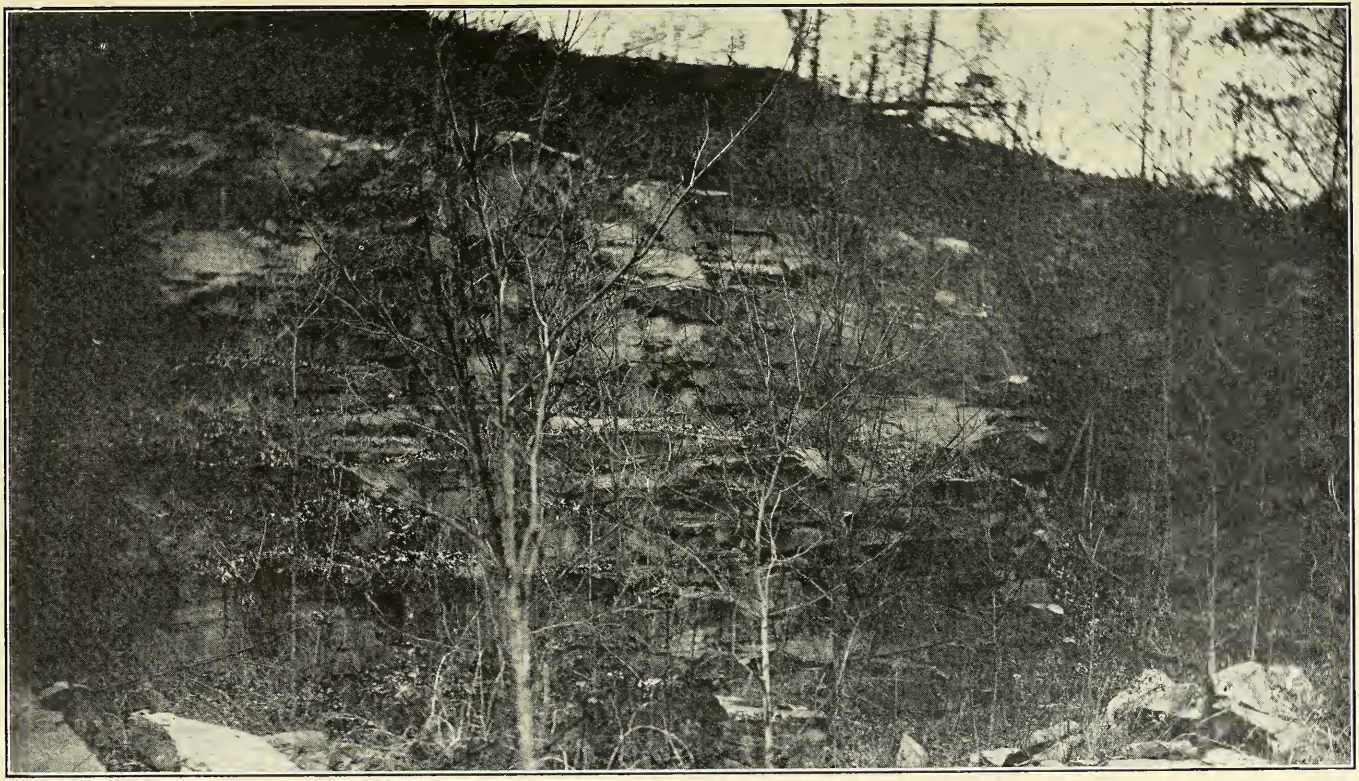

PLATE XV.—Clayton Sandstone (type locality) at abandoned quarry of Alderson Brownstone Company along road descending into Griffith Creek 1.2 miles northeast of Clayton, Summers County. See Glenray Section. (Photo. by Palmer & Fowler).

Ernest Plumley Coal Prospect—No. 752 on Map VI. Local Measurement at Fossil Lots 226 and 226A.

Greenbrier District, Summers County; just southwest of the summit of Elk Knob of Keeney Mountain 0.9 mile northwest of Judson; gentle northwest dip; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Pottsville Series—Pocahontas Group (60′)		
1. **Sandstone, Keystone,** gray, massive, coarse, with a few pebbles; contains plant fossils at base (see **Lot 226**)	40	40
2. **Coal, Keystone,** reported as an impure and sulphurous streak (3440′ B.) (**Prospect No. 752, on Map VI**), hole fallen shut	..	40
3. **Shale, North Fork,** black, fissile, on old dump, thickness concealed; contains a sparse, brackish-water fauna, pelecypods (**Naiadites**) and ostracods (see **Lot 226A**)	..	40
4. Concealed and sandy shale (3420′ B.)	20	60
5. Shale, red, **Bluestone Group of Mauch Chunk Series**	..	..

Elsewhere in the region no coal was observed at this horizon, even at points where strata were exposed. There appears to be no ground for belief that any appreciable amount of good coal can be recovered from the seam.

NORTH FORK SHALE.

The **North Fork Shale** of Hennen[17], belonging a few feet below the Keystone Coal, and generally described as black and fissile, with lenses of iron, and carrying a fresh- or brackish-water fauna, and as having a variable thickness, was observed at a few localities in northern Summers County. In the western slope of Hump Mountain it is 55 feet thick, greenish-gray, sandy, and ferruginous, coming just under the Keystone Coal, as recorded in the New Richmond Section, page 242. Farther south, as detailed above, it was observed at the **Ernest Plumley Coal Prospect (No. 752 on Map VI),** on the southern slope of Elk Knob of Keeney Mountain, where it is black and fissile but not well enough exposed for a determination of its thickness. Here it carries **Naiadites** and

[17]Ibid., p. 239.

ostracods, for a discussion of which by Dr. Girty see Chapter XVIII.

Elsewhere in the region it was not observed and at various points where the strata are well exposed it appears to be entirely absent.

ECONOMIC ASPECTS, POTTSVILLE SERIES.

The good coals of the Pottsville Series are its principal economic feature. In western Mercer County, which is outside the previously mentioned boundaries of this Report, these coals have been extensively exploited, there being many large mining plants, as Mr. Krebs has already described in the Raleigh Report of the Survey. In the western edge of Summers County some of these coals continue northward, but, owing to their distance from the railroad and their height in the mountains, no attempt has been made to mine them. On the east side of New River in the same county two of these coals have minable thickness in a few isolated knobs and on Hump Mountain there is one plant in operation.

Some of the massive sandstones of the series could be used for masonry construction, the Keystone ledge being apparently a very good quarry rock, but their isolation in the high mountain tops would make it difficult to market the product. The possibility of using the Pineville Sandstone for glass-sand has already been mentioned.

The shales of that portion of the Pottsville herein described are too sandy or too much impregnated with carbonaceous matter to be regarded with favor for brick making or other ceramic uses.

CHAPTER VII.

STRATIGRAPHY---MAUCH CHUNK SERIES.

GENERAL ACCOUNT AND SECTION, MAUCH CHUNK SERIES.

The Mauch Chunk Series of the Mississippian, coming at the top of this period and lying just below the Pottsville Series of the Pennsylvanian, forms the most extensive outcrop and is one of the most interesting series of the three counties. As originally defined by Ashburner[1] it was called the "Mauch Chunk Red Shale" and this usage was followed by Platt, Stevenson, Chance, White, Lesley and others of the Second Geological Survey of Pennsylvania, its equivalent designation as "No. XI" being used at the same time. The description of this formation as a simple shale was eminently proper at its type locality in northeastern Pennsylvania where it contains few distinctly bedded sandstones, no coals, and only rare lentils of limestone, and the same simplicity continues southwestward across Maryland. In West Virginia, however, it soon loses its monotonous character, there being some comparatively heavy sandstones even in the northern part of the State, while farther south and southwest there are many more sandstones, frequent limestones, and occasional coals, as well as much variety in the shales. In conformity with this more complex nature it was described as the "Mauch Chunk Series" by Hennen[2] in 1913 and this more comprehensive usage has since been generally employed in the West Virginia Reports. In Mercer and Summers Counties the more complex nature of these rocks was fully appreciated by Campbell[3] and they were divided into logical groups, as will be later detailed under

[1]C. A. Ashburner, Am. Phil. Soc. Proc., Vol. XVI, pp. 521, 536; 1877.

[2]Ray V. Hennen, Monongalia, Marion, and Taylor Report, W. Va. Geol. Survey, pp. 381-382; 1913.

[3]M. R. Campbell, Pocahontas Folio, No. 26, U. S. Geol. Sur.; 1896.

the subject of "Subdivisions", but at the same time their identity with the Mauch Chunk of Pennsylvania was almost wholly ignored, the only statement in this respect being that the Bluefield Group represented the "Upper portion of Roger's No. XI".

In Mercer, Monroe, and Summers Counties the Mauch Chunk Series varies from 2,200 to 3,450 feet, the greatest measured thickness of 3,238 feet being visible in the Hurricane Ridge Syncline north of Bluefield where the sedimentation of the formation appears to have reached its West Virginia maximum but where a small portion of the top has evidently been eroded. In these counties it is composed of alternating beds of sandstone, shale, and limestone, with lenticular streaks of coal, there being much variety in the character of these lithologic components. The sandstones are partly green, flaggy, and micaceous, partly red and shaly, partly greenish-gray, brown or even white, and massive, while there is one well-defined ledge that is abundantly conglomeratic with partly rounded white quartz pebbles and with frequent inclusions of abraded limestone particles. With the exception of this (Princeton) ledge, however, quartz pebbles are almost totally absent but the limestone fragments are more common, being present in several of the ledges in the upper third of the series. The shales of the upper two-thirds are predominantly red and when so colored are generally though not wholly barren of organic remains, but within or adjacent to these heavy red beds there are frequent greenish, fissile and slightly calcareous or brown and ferruginous, shales which often carry abundant marine and occasional plant fossils. In the lower third of the series the shales become more calcareous and more abundantly marine, and at the extreme base there is one heavy bed that is persistently dark and fissile, being almost black at some localities. The limestones in the upper half are usually lenticular, thin, and impure, although frequently marine, but near the middle there is a heavy bed of more compact and more abundantly marine limestone (Avis) which may nearly always be found at the regions of its outcrop. Toward the base, limestones of a massive and persistent character become

so common and so much filled with fossil forms that the lower contact with the underlying Greenbrier Series may be quite easily mistaken.

Within the series eleven thin and lenticular coals have been noted, being confined to no particular group or stage but being well distributed through the vertical column. These coals are almost invariably thin and impure, their principal value being as correlation planes in which respect they are of much scientific interest because of the plant fossils contained in the roof shales.

The following general section, prepared by the writer from many measured sections and local notes, names the various beds of the series and indicates their nature in the three counties and surrounding territory:

General Section of the Mauch Chunk Series for Mercer, Monroe, and Summers Counties, West Virginia.

	Thickness. Feet.	Total. Feet.	Intervals. Feet.
Bluestone Group (400′ to 800′)			
1. Shales, red and variegated, and sandstone, greenish-brown, flaggy, and micaceous, not well enough exposed for detailed classification	50 to 200	200	
2. **Sandstone, Bent,** greenish-brown, micaceous, flaggy or massive; well exposed near top of Bent Mountain, Mercer County, at elevation 2910′ B.	40 to 60	260	260
3. **Shale, Upper Bent,** red and variegated, or black and fissile, with marine fossils	20 to 40	300	
4. **Limestone, Bent,** lenticular, with ostracods	0 to 1	301	
5. **Shale, Lower Bent,** green, argillaceous and fissile, with marine fossils	10 to 18	319	
6. **Coal, Hunt,** lenticular, visible in road near Hunt School, Mercer County, at elevation 2625′ B.	0 to 1	320	60
7. **Sandstone, Hunt,** green, massive or shaly	10 to 20	340	
8. **Shale, Hunt,** green, or red and variegated	10 to 20	360	
9. **Sandstone, Bratton,** green, flaggy, and fine-grained, with occasional massive layers, visible in road near head of Bratton Branch, Mercer County	10 to 20	380	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
10.	**Shale, Bratton,** red, or greenish-brown and sandy	25 to 30	410	
11.	**Sandstone, Upper Belcher,** greenish-gray, medium-coarse, massive; exposed in road both north and south of Belcher School, near Princeton, Mercer County	15 to 25	435	115
12.	**Shale, Upper Belcher,** red, with lenticular streak of carbonaceous fire clay near middle, and with marine fossils	15 to 20	455	
13.	**Sandstone, Lower Belcher,** greenish-gray, massive, or flaggy, and micaceous	15 to 25	480	
14.	**Shale, Lower Belcher,** red or sandy, with occasional marine fossils, mostly pelecypods (see Lot 206)	20 to 30	510	75
15.	**Sandstone, Upper Mud,** brown, micaceous, visible on Mud Fork of Bluestone River, Tazewell County, Virginia	0 to 5	515	
16.	**Shale, Upper Mud,** red	20 to 25	540	
17.	**Sandstone, Lower Mud,** greenish-gray or brown	0 to 5	545	
18.	**Shale, Lower Mud,** red and variegated or dark-green and sandy	15 to 20	565	
19.	**Sandstone, Glady Fork,** greenish-brown, coarse, massive, with plant fossils at base (see Lot 236); exposed on Brush Creek, southwest of mouth of Glady Fork, near Princeton	25 to 40	605	95
20.	**Shale, Pipestem,** sandy, with streaks of sandstone, and with plant fossils at base (see **Lot 240**); also contains marine fossils, mostly pelecypods (see **Lot 205**)	30 to 44	649	
21.	**Coal, Pipestem,** lenticular streak, visible near Pipestem Knob, Summers County	0 to 1	650	
22.	**Shale, Pride,** greenish-brown, sandy, fissile, often weathering into pencil-like forms; contains occasional marine fossils (see **Lot 204**); exposed near Pride, Mercer County	70 to 150	800	195
Princeton Conglomerate (20′ to 50′)				
23.	**Sandstone, Princeton,** greenish-gray, massive, extremely hard and nearly always conglomeratic with quartz pebbles; also contains limestone conglomerate at base; occasional plant fossils; exposed in Virginian Railway cut just north of Princeton Station	20 to 50	850	50

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
Hinton Group (800′ to 1350′)				
24.	**Shale, Terry,** greenish-brown, sandy, with occasional lentils of coal and streaks of red shale; contains plant fossils (see Lots 237, 238, and 239).	15 to 50	900	
25.	**Limestone, Terry,** gray, with marine fossils, described as occurring near Terry, Raleigh County; apparently represented in territory of this Report by a ferruginous but abundantly marine band with brachiopods, pelecypods, and trilobites (see Lots 126, 184, and 189)	2 to 0	900	
26.	**Shale, Pluto,** greenish-brown, sandy, slightly ferruginous, fissile, usually weathering into pencil-like forms; contains marine fossils in streaks or zones; first noted on Leatherwood Creek, Webster County	25 to 38	938	
27.	**Coal, Pluto,** lenticular, slaty, and impure, first described as occurring near Pluto, Raleigh County	0 to 2	940	90
28.	**Limestone, Pluto,** shaly, with marine fossils, crinoids, brachiopods, and gastropods; visible on Tallery Mountain road south of True, Summers County	0 to 2	942	
29.	**Shale, Lower Pluto,** greenish-brown, sandy, with occasional reds, and streaks of sandstone; contains marine fossils, mostly pelecypods among which **Myalina** is common (see Lots 190, 191, and 192); also contains a plant fossil zone near base	50 to 78	1020	
30.	**Sandstone, Falls Mills,** greenish-gray, shaly or massive; makes falls across Bluestone River at Falls Mills, Tazewell County, Virginia	25 to 50	1070	130
31.	**Shale, Falls Mills,** calcareous or variegated with reds; lenticular sandstone in lower portion; shale contains marine fossils, pelecypods (chiefly **Myalina**) and ostracods (see Lots 210 and 249)	25 to 40	1110	
32.	**Limestone, Falls Mills,** yellow, shaly, lenticular, with marine fossils, pelecypods and many ostracods (see Lots 193 and 250)	0 to 5	1115	
33.	**Shale, Upper Fivemile,** gray or green and calcareous, with marine fossils, pelecypods and ostracods (see Lots 194 and 211); occasionally red and variegated, with lenticular sandstone	15 to 24	1139	
34.	**Coal, Fivemile,** lenticular, visible on Fivemile Creek, Mercer County	0 to 1	1140	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
35.	**Shale, Lower Fivemile,** green and sandy, with marine and plant fossils, pelecypods (especially **Myalina**), ostracods, and annelids (**Spirorbis**) (see Lot 195).....	10 to 20	1160	
36.	**Sandstone, Tallery,** usually green and shaly but sometimes massive; quarried on road just east of Athens, Mercer County.....	15 to 25	1185	115
37.	**Limestone, Tallery,** yellow and shaly, with marine fossils.....	1 to 2	1187	
38.	**Shale, Upper Tallery,** greenish-yellow, with marine fossils, largely pelecypods (especially **Myalina**) (see Lot 196); and with plant fossils (see **Lot 241**)	10 to 13	1200	
39.	**Coal, Tallery,** lenticular streak; outcrops on Tallery Mountain road south of True, Summers County, at elevation 2110′ B.....	1 to 0	1200	
40.	**Shale, Lower Tallery,** red and variegated	25 to 35	1235	
41.	**Sandstone, Low Gap,** greenish-gray, shaly or massive; visible along Wolf Creek Mountain road east of Low Gap School, near Bertha, Summers County	20 to 30	1265	
42.	**Limestone, Low Gap,** yellow, shaly or sandy, with marine fossils.....	1 to 2	1267	
43.	**Shale, Low Gap,** red and variegated.	5 to 8	1275	
44.	**Sandstone, Avis,** greenish-gray, massive or shaly.....	30 to 35	1310	
45.	**Shale, Upper Avis,** green, calcareous, with marine fossils, pelecypods (**Myalina,** etc.) (see Lots 197 and 203)	20 to 25	1335	
46.	**Limestone, Avis, (Hinton Limestone** of Krebs in Raleigh County Report), steel-gray, hard, with shaly streak near middle. Contains abundant marine fossils, brachiopods, pelecypods, gastropods, crinoids, bryozoa, etc. (see Lots 125, 160, and 198); visible at numerous points around Avis and Hinton, Summers County, and quarried on Laurel Creek east of Athens, Mercer County	20 to 40	1375	190
47.	**Shale, Lower Avis,** yellow, calcareous, with marine fossils, pelecypods, brachiopods, ostracods (see **Lot 199**)	20 to 30	1405	
48.	**Sandstone, Payne Branch,** greenish-gray, shaly; visible on Payne Branch of Fivemile Creek 2.2 miles north of Hatcher, Mercer County..	20 to 35	1440	
49.	**Shale, Payne Branch,** red and variegated	15 to 20	1460	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
50.	**Sandstone, Hackett,** greenish-gray, massive, but often made up of thick, hard flags, separated by streaks of shale; makes plateau east of the head of Hackett Creek, Mercer County	30 to 45	1505	130
51.	**Shale, Hackett,** red, with occasional streaks of sandstone or limestone, contains marine fossils in lower portion (see Lot 212)	100 to 200	1705	
52.	**Limestone, Tophet,** shaly, with marine fossils, visible in road just northeast of Tophet, Summers County, at elevation 1990′ B	3 to 5	1710	
53.	**Shale, Upper Tophet,** red	10 to 15	1725	
54.	**Sandstone, Tophet,** shaly	15 to 25	1750	
55.	**Coal, Tophet,** lenticular streak; outcrops in Tallery Mountain road south of True, Summers County, at elevation 1695′ B	1 to 0	1750	
56.	**Shale, Lower Tophet,** mostly red and variegated with streaks of sandstone; plant fossils at top (see Lot 242)	20 to 35	1785	
57.	**Sandstone, Goodwyn,** greenish-gray and massive, or reddish and shaly; makes prominent cliff just above drainage on Fivemile Creek at Goodwyn Chapel, Mercer County	25 to 40	1825	320
58.	**Shale, Upper Goodwyn,** dark, sandy, fissile, with marine fossils, pelecypods (largely **Myalina**), and ostracods (see **Lot 213**)	5 to 10	1835	
59.	**Coal, Goodwyn,** lenticular streak; shows as a carbonaceous shale with plant fossils at Goodwyn Chapel, Mercer County	1 to 0	1835	
60.	**Shale, Lower Goodwyn,** dark and calcareous, with marine fossils near top; red and variegated with streaks of sandstone toward base	40 to 75	1910	
61.	**Sandstone, Upper Bellepoint,** reddish-brown or greenish-gray, medium-coarse, sometimes massive but often shaly, frequently forms cliffs; visible in wooded slope north of Bellepoint, Summers County	30 to 40	1950	125
62.	**Shale, Upper Bellepoint,** red and variegated, or greenish-gray and sandy with streaks of limestone; contains marine fossils, pelecypods and many ostracods (see Lot 201)	30 to 35	1985	
63.	**Sandstone, Middle Bellepoint,** greenish-gray, or reddish-brown, usually shaly but often form cliffs	15 to 25	2010	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
64.	**Limestone, Middle Bellepoint,** yellow, shaly, lenticular, with marine fossils; visible on Keeney Mountain road southeast of Hinton at elevation 1545′ B.	0 to 3	2013	
65.	**Shale, Middle Bellepoint,** often red and variegated but sometimes greenish-gray and sandy, with marine fossils, pelecypods and ostracods (see **Lots 183** and 202); also plant fossils (see Lot 243); occasional streaks of limestone.....	25 to 37	2050	
66.	**Sandstone, Lower Bellepoint,** greenish-gray or reddish-brown, usually shaly but often forms cliffs.....	15 to 25	2075	
67.	**Shale, Lower Bellepoint,** red and variegated, or greenish-gray and sandy, with plant or marine fossils, pelecypods, brachiopods, ostracods, and fish remains (see Lots 209 and 253); occasional streaks of limestone	30 to 40	2115	
68.	**Sandstone, Stony Gap,** (Hinton of Stevenson), gray or white, coarse, massive, extremely hard and quartzitic but without pebbles; makes great vertical reef in crest of Stony Ridge, Mercer County; also prominent at numerous other localities including Hinton Station; contains plant fossils at base (see **Lot 235**)..	35 to 85	2200	250
Bluefield Group (800′ to 1250′)				
69.	**Limestone, Coney,** greenish-yellow, shaly, lenticular, with occasional marine fossils (see Lot 185).....	0 to 3	2203	
70.	**Shale, Coney,** red, variegated, and sandy, with marine fossils, pelecypods (including **Myalina**), brachiopods, gastropods, cephalopods, and many ostracods (see Lots 161, 207, 221, and 225); also contains a persistent plant fossil zone (see **Lot 244**); occasional streaks of sandstone or limestone.....	53 to 67	2270	
71.	**Sandstone, Clayton,** reddish-brown, fine-grained, quarried on road to Griffith Creek northeast of Clayton, Summers County, at elevation 2050′ B.	20 to 30	2300	100
72.	**Shale, Clayton,** red and variegated or greenish, with marine fossils, pelecypods (especially **Sphenotus**) (see **Lots** 164 and 245); streaks of sandstone	50 to 80	2380	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
73.	**Sandstone, Graham,** greenish-gray, shaly, probably correlates with **Big Spruce Knob Sandstone** of Webster County Report	15 to 30	2410	
74.	**Limestone, Graham,** gray and shaly, with marine fossils (see **Lot 123**)	2 to 3	2413	
75.	**Shale, Upper Graham,** gray, ferruginous, and calcareous, with marine fossils in upper portion and plant fossils at base, pelecypods, (especially **Myalina** and **Sphenotus**), and ostracods (see **Lots 123, 124,** 208, 234; probably correlates with **Big Spruce Knob Shale** of Webster County Report	20 to 30	2443	
76.	**Coal, Graham,** slaty and impure, once mined for local use one-half mile northwest of Graham, Virginia; probably correlates with **Big Spruce Knob Coal** of Webster County Report	1 to 2	2445	145
77.	**Shale, Lower Graham,** red, variegated, and sandy, with thin sandstones	50 to 75	2520	
78.	**Sandstone, Bertha,** greenish-gray, shaly, visible in road east of Bertha, Summers County, at elevation 1555′ B.; contains plant fossils (see **Lot 124**)	30 to 50	2570	125
79.	**Shale, Upper Bertha,** sandy, with occasional plant or marine fossils	45 to 75	2645	
80.	**Limestone, Bertha,** yellow and impure, with marine fossils, brachiopods (especially **Orthotetes**) and pelecypods (see Lot 162)	2 to 15	2660	
81.	**Shale, Lower Bertha,** greenish-yellow, with marine fossils; also streaks of limestone and red shale	65 to 90	2750	
82.	**Sandstone, Bradshaw,** greenish-gray, shaly or massive, medium-grained, makes cliffs on mountain road northeast of Indian Mills, Summers County, at elevation 1615′ B., and on Bradshaw Creek west of Bradshaw School	30 to 50	2800	230
83.	**Limestone, Bradshaw,** shaly and siliceous, lenticular; contains marine fossils, brachiopods and pelecypods (see Lot 187)	0 to 3	2803	
84.	**Shale, Bradshaw,** usually red and variegated but sometimes greenish and sandy, with marine fossils, pelecypods; also plant fossils (see Lot 230); contains lenticular coal seam (**Red Sulphur Coal**) on Fitz Run south of Red Sulphur Springs, Monroe County	30 to 37	2840	

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
85.	**Sandstone, Indian Mills,** greenish-gray, fine-grained, massive in part, with streaks of shale; makes prominent outcrop on Indian Creek just west of Indian Mills, Summers County	30 to 60	2900	100
86.	**Shale, Indian Mills,** green, or red and variegated, with marine fossils, pelecypods (**Sphenotus** and **Myalina**) (see **Lots** 159A and **165**); also plant fossils (see **Lot 159**)	60 to 70	2970	
87.	**Limestone, Raines Corner,** dark, hard, weathering gray, with marine fossils, brachiopods, pelecypods, and gastropods (including **Bellerophon** at nearly all outcrops), (see **Lots** 43A, **158,** 167, 186, 220, 222, 248, and 252); also fucoidal; visible in bed of Indian Creek one-half mile northwest of Raines Corner, Monroe County	5 to 10	2980	
88.	**Shale, Raines Corner,** sandy, with marine and plant fossils	5 to 8	2988	
89.	**Coal, Raines Corner,** slaty and impure, quite persistent in western Monroe County	1 to 2	2990	90
90.	**Shale, Possumtrot,** dark, sandy, with streaks of sandstone and with plant fossils (see **Lot 229**); visible along Indian Creek road 0.3 mile north of Possumtrot Branch, Monroe County.	4 to 25	3015	
91.	**Sandstone, Droop,** white, very coarse and soft, weathering into white sand; forms the surface of Droop Mountain, Pocahontas County, for several miles along State road through Spice; also prominent in the top of Swoopes Knobs west of Union and in other mountains southeast of Alderson, Monroe County	40 to 60	3075	85
92.	**Shale, Talcott (Clore** age), gray and sandy, with marine fossils, brachiopods, pelecypods, bryozoa, and cephalopods (see **Lots** 182 and **188**); exposed beneath cliff of Droop Sandstone along road on south side of Greenbrier River one-half mile southeast of Talcott, Summers County	15 to 25	3100	
93.	**Shale, Ada (Clore** age), olive-green, fissile, calcareous towards base, with profuse marine fossils, fenestelloid bryozoa very common, brachiopods (**Spirifer, Productus,** etc.) (see Lots 43A, 120, 154, 181, 216, 223, and **251**); visible in highway just west of Ada, Mercer			

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
	County, and apparently present at nearly all points where its horizon should belong in all three counties.	30 to 60	3160	
94.	**Limestone, Reynolds (Clore age)**, gray, shaly, with profuse marine fossils, brachiopods (**Orthotetes** especially prominent), bryozoa, gastropods, and cephalopods, (see Lots 120, 156, 157, 168, **180**, 217, and 224); outcrops in road at western edge of Swoopes Knobs plateau 0.3 mile east of Reynolds School and 0.6 mile northwest of Knobs and also in extreme top of Bickett Knob, Monroe County	10 to 15	3175	100
95.	**Shale, Bickett**, red or sandy	20 to 25	3200	
96.	**Sandstone, Webster Springs (Palestine age)**, greenish-gray, flaggy or shaly, fine-grained; forms Lover's Leap on Elk River at Webster Springs, Webster County	5 to 10	3210	
97.	**Limestone, Glenray (Menard age)**, gray, usually hard and somewhat sandy but sometimes shaly, numerous marine fossils, brachiopods, bryozoa (including **Archimedes**), and fish teeth (see Lots 14, 169, 215, **219**, and 255); visible on west side of Greenbrier River at mouth of Griffith Creek, opposite Glenray, Summers County; appears to contain within its mass a lenticular coal (**Nemours Coal**), at Nemours Station, Mercer County	80 to 125	3335	160
98.	**Shale, Lillydale (Menard age)**, dark-green, or greenish-gray at top, black and carbonaceous at base, fissile, with some included lenses of iron carbonate and limestone; contains marine fossils, numerous brachiopods (especially **Spirifer**), pelecypods (**Sulcatopinna** in northern West Virginia), gastropods, and cephalopods (see Lots 121 and 246); apparently indivisible in territory of this Report but elsewhere sometimes contains in its lower part a gray, lenticular, flaggy sandstone (**Edray Sandstone** of **Tar Springs** age), visible in road one mile north of Edray, Pocahontas County, at elevation 2925′ B.; this shale appears to be the same as the **Pencil Cave** of the oil region of West Virginia; makes abundant outcrop on head of Back Creek at Lillydale, Monroe County	80 to 115	3450	115
Greenbrier Series		..	...	....

A study of the above section from a lithologic standpoint shows that, exclusive of the upper 200 feet, which are not definitely classified, the series contains approximately 30.8 per cent. of sandstone, 61.7 per cent. of shale, 7.2 per cent. of limestone, and 0.3 per cent. of coal.

In the above section it has not been possible to classify in detail the estimated upper 200 feet. Exposures of this portion of the Bluestone Group, which appears to attain its maximum thickness in the Hurricane Ridge Syncline, are fragmentary and incomplete in Mercer County, West Virginia; and in Tazewell County, Virginia, where the beds may be slightly thicker than in Mercer, they are not only much concealed by debris but are also crushed and duplicated by sharp folding so that an attempt to separate them into members would not appear advisable. Farther north and northwest there are undisturbed horizontal exposures of the group but the upper 200 feet in question have in most instances partly or wholly thinned away.

In previous Reports of the Survey[4] several general sections of the Mauch Chunk Series have been published but these have been principally compiled to show the positions of a few conspicuous members without any attempt to make detailed classifications of all the beds. Most of them, also, apply to counties where the series is much thinner than in the region under study. In the present section the writer has adopted as much of the previous nomenclature of members as has been possible without conflicts or uncertainties. Several beds were named by Krebs in the Raleigh County Report among which the Terry Limestone and Pluto Coal are retained, but the name of "Hinton Limestone" has been changed to Avis Limestone because of the very obvious conflict with the name of the Hinton Group in which this formation occurs; and the "Hinton Sandstone" of Stevenson, which was used by Krebs in the Report mentioned and which has admitted priority, has been regretfully put into parentheses, and the

[4]Ray V. Hennen, Fayette Report, p. 113 (1919); David B. Reger, Webster Report, p. 214 (1920); Nicholas Report, pp. 352-353 (1921); Tucker Report, p. 227 (1923); and Mineral and Grant Report, p. 273 (1924); W. Va. Geol. Survey.

name Stony Gap substituted because of the wide usage of Hinton as a group name in many Government Reports on West Virginia and Virginia. In the Wyoming and McDowell Report four sandstones (Pageton, Hartwell, Ballard Harmon, and Anawalt) were named by Hennen but these are described mainly by interval from the No. 3 Pocahontas Coal or from the top of the Mauch Chunk Series without their inclusion in any measured sections of such detail as to afford a correlation with the rocks of other counties. In Webster County the Pluto Shale, "Big Spruce Knob Sandstone", "Big Spruce Knob Shale", "Big Spruce Knob Coal", and Webster Springs Sandstone were named by Reger, of which it has been possible to retain the Pluto Shale and the Webster Springs Sandstone. In the case of the Big Spruce Knob stage there is much evidence for belief that these correlate with the Graham stage of the present section but these three names have been put in a secondary position until more positive data can be secured.

In the present section, also, certain new names have been adopted from localities entirely outside of the three counties, their use having resulted from an extended correlation trip in which the series was studied in other counties and States. These few outside names were for various reasons considered more appropriate than any local titles that might have been employed.

The writer now has under preparation a special volume on the Mississippian Period which, among other things, will include a review of the Mauch Chunk Series from its type locality in Pennsylvania to its counterparts in southern Tennessee. It will be possible in that volume to amplify the general section so as to indicate many members which can be definitely traced outside the limits of West Virginia but it is not thought expedient to record these more extended correlations in the present Report except in a few of the lower members where adequate descriptions in other States are available. In such cases the relationships have been indicated in parentheses.

SUBDIVISIONS, MAUCH CHUNK SERIES.

The rocks of the Mauch Chunk Series in Mercer and Summers Counties were long ago subdivided by Campbell[5] into four major groups, in the following descending order:

Bluestone Formation (Group)
Princeton Conglomerate
Hinton Formation (Group)
Bluefield Shale (Group).

These four subdivisions are logical and well adapted to any further studies of the series that may be made and they are herein employed, but "Group" has been substituted for "Formation", since the two are synonymous except that "Formation" has generally been used as a temporary local designation and should therefore be abandoned in favor of "Group" when the title has become firmly fixed and widely applied in correlations, as is the case in the present instance. In the case of the Bluefield "Shale" the subdivision is made up of many distinct beds, including limestones, sandstones, and coals, as well as shales, so that the title of "Shale" is so clearly a misnomer that "Group" is substituted in the belief that clarity will result.

It has already been mentioned that the four subdivisions of Campbell were originally used as independent group or formation names without reference to the obvious fact that these are simply portions of the Mauch Chunk Series, the only hint at such a relationship having been that the Bluefield Group represented a portion of the No. XI of Rogers. The very evident but long deferred assignment of these four groups to the Mauch Chunk Series is now herein expressed.

The more minute subdivision of the Bluestone, Hinton, and Bluefield Groups into members has also been accomplished in the general section, the Princeton being an altogether indivisible lithologic bed.

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[5]M. R. Campbell, Pocahontas Folio, No. 26, U. S. Geol. Survey: 1896.

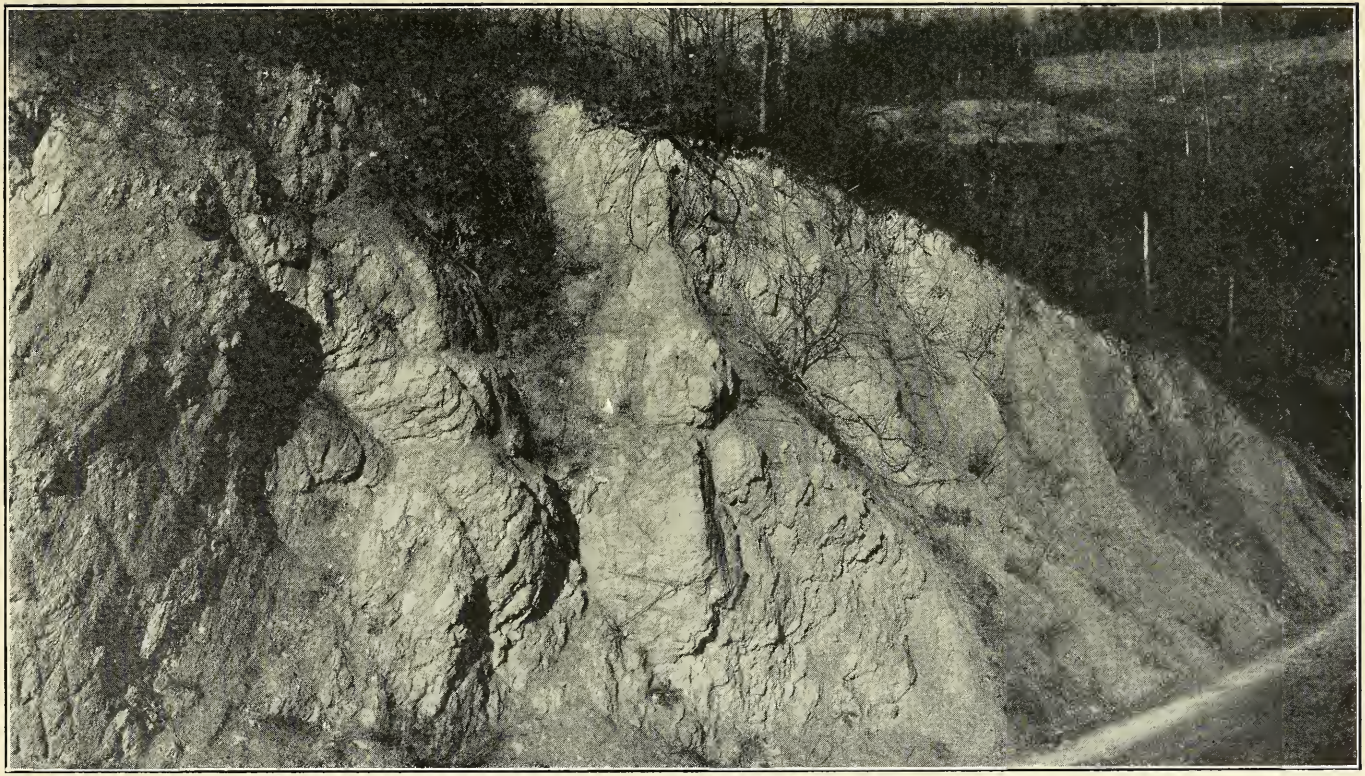


PLATE XVI.—Ada Shale (right) and possibly a shaly exposure of Reynolds Limestone (left), on Bluefield-Princeton road 0.3 mile southwest of Stony Gap, Mercer County, looking northwestward. Beds overturned and now dipping southeastward. See Stony Gap Section. (Photo. by Palmer & Fowler).

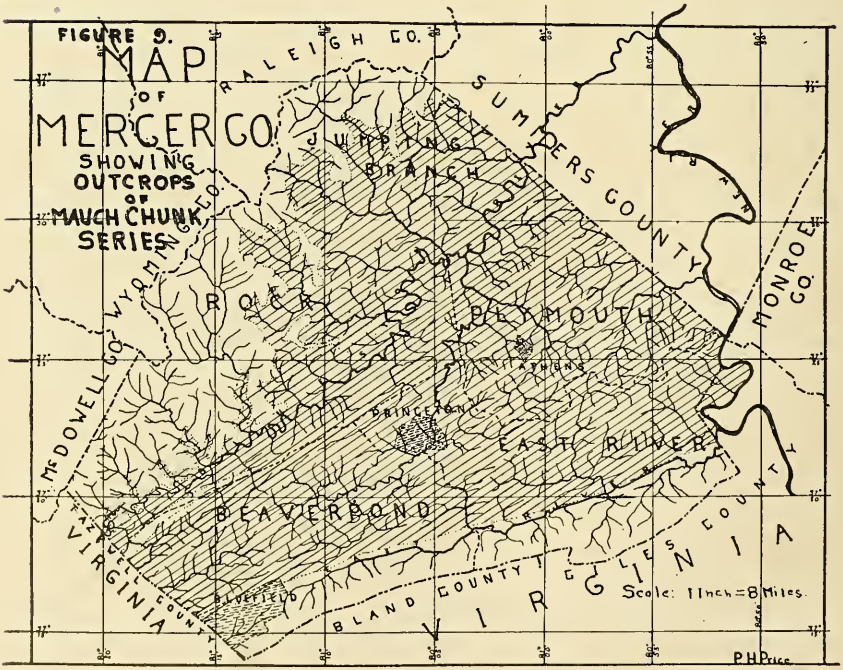
TOPOGRAPHIC EXPRESSION, MAUCH CHUNK SERIES.

In localities where there are no modifying external influences, like the presence of overlying Pottsville beds or distortion by violent folds, the topography of the Mauch Chunk Series usually resolves itself into comparatively narrow ridges, each of which is capped by a hard sandstone that is usually a worn remnant of one of the old peneplains. From the edges of these narrow plateaus the descent of the hills is usually abrupt until another durable sandstone interrupts the steep angle of repose and forms a shelf, or in some cases a subsidiary plateau that may be of greater width than the one which caps the ridge. The same succession of steep, shaly slopes followed by sandstone benches is often repeated two or three times until the deep valley floor is reached. These valleys are usually narrow because of the evidently youthful cycle of the major streams, and raggedly V-shaped because of the benching of the hillsides. In the region around Princeton an extensive upland plateau is preserved mainly by the Princeton Conglomerate, the streams being still in a state of base-level. Along Tallery Mountain and Keeney Mountain there are also extensive shelves made by the same bed. In Monroe County north of Peterstown the Stony Gap Sandstone is the main plateau factor, being generally found at the tops of the ridges, while farther north in the same county the Droop Sandstone is the cap rock of Swoopes Knobs, Flattop Mountain, and other bold ridges.

AREAL EXTENT, MAUCH CHUNK SERIES.

Figures 9, 10, and 11, respectively, indicate the outcrops of the Mauch Chunk Series in Mercer, Monroe, and Summers Counties; and Maps II, IV, and VI show the same outcrops in much greater detail. By these figures and maps it is evident that about 75 per cent. of the surface of Mercer County is Mauch Chunk, while in Monroe the percentage is about 30, and in Summers about 95, so that these rocks form more than

half of the whole area of the three. In Mercer the belt occupies the central and major zone of the county, there being a comparatively narrow strip of Pottsville along the northwestern border, and another strip of older sediments along the southern edge. In Monroe the outcrops are in the northwestern third, next to Summers County, there being some belts of Greenbrier along the Abbs Valley Anticline and other uplifts within the area mentioned. In Summers County the Mauch Chunk outcrop is complete except for a fringe of Pottsville along the western edge, a few isolated knobs of the same series in the northern part, and a few narrow exposures of Greenbrier along Greenbrier River west of Alderson.



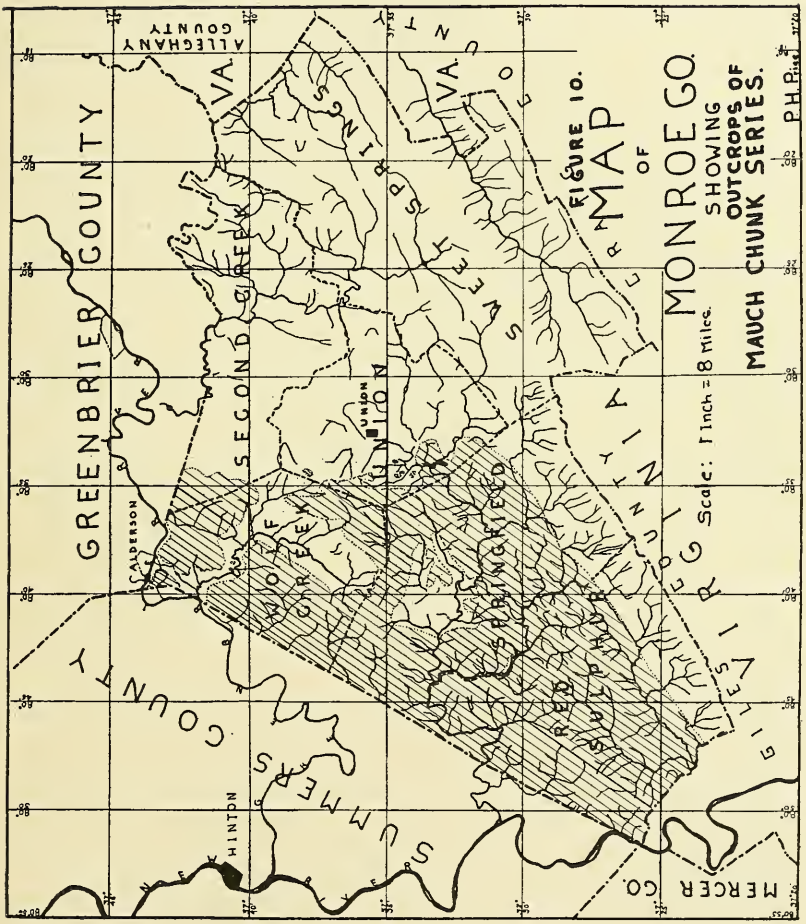
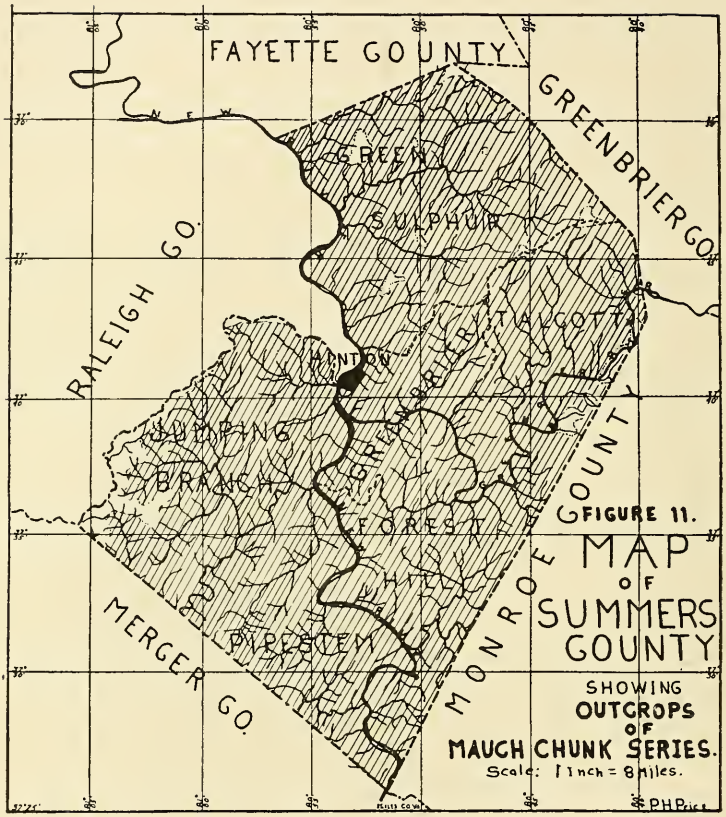


FIGURE 10.
MAP
OF
MONROE CO.
SHOWING
OUTCROPS OF
MAUCH CHUNK SERIES.
P.H.P.
Scale: 1 Inch = 8 Miles.
GREENBRIER COUNTY
ALLEGHANY COUNTY
SUMMERS COUNTY
MERCER CO.
VA.
VA.
SWEET SPRINGS
UNION
SECOND CREEK
CALDERSON
HINTON
RED SULPHUR SPRINGS
ALLEGHANY MTNS.
ALLEGHANY FRONT



CONTACTS, MAUCH CHUNK SERIES.

The contact of the Mauch Chunk Series with the overlying Pottsville and the wide unconformity that exists at this boundary have already been discussed under the description of the latter series. At the base of the Mauch Chunk there is a much less evident lapse of time or change in physical conditions. Aside from the paleontologic changes, which Dr. Girty will doubtless discuss in Chapter XVIII, the general difference between the lower part of the Bluefield Group of the Mauch Chunk and the underlying Greenbrier Series is

one of degree rather than of startling change. In the Greenbrier of the three counties the beds consist mainly of massive limestones of varying character, sandstones being almost totally absent and shales of thin and infrequent occurrence. At the base of the Bluefield Group of the Mauch Chunk there is a heavy and persistent stage of dark and carbonaceous shale, followed above by limestone and sandstone, the first appearance of red shale being usually about 250 feet above the top of Greenbrier. On the evidence of these three counties it might be inferred that some of the basal limestones of the Bluefield more properly belong in the Greenbrier, but in tracing this contact zone northeastward up the Greenbrier Valley it may be noted that the basal shales of the Bluefield often become red instead of carbonaceous, making the boundary more impressive.

FOSSIL LIFE, MAUCH CHUNK SERIES.

In the Mauch Chunk Series of the three counties there are abundant remains of marine invertebrate life, there being fossils in not less than 44 of the members listed in the general section and possibly other similar horizons which escaped attention. These fossils are well distributed through the Bluestone, Hinton, and Bluefield Groups, there being apparently none in the Princeton Conglomerate, but in general they are much more abundant toward the base of the series than in the upper part. In the Bluestone Group most of the forms are ostracods and pelecypods, but in the Hinton Group there is a greater diversity owing to the presence of more limestones, while in the Bluefield both the classes and the individual numbers are much further increased. Numerous collections were made in the field by the writer, with the field help also of Dr. George H. Girty of the United States Geological Survey for a week, and with some further assistance from Dr. Wm. F. Prouty and Paul H. Price of the West Virginia Survey Staff. Dr. Girty has kindly undertaken the study of these collections and his lists and discussions will be found in Chapter XVIII.

No vertebrate remains of any description were noted in the series in the three counties, although at Pottsville, Penn-

sylvania, and other localities in the vicinity of the Mauch Chunk type locality there are abundant reptilian tracks, including **Palaeosauropus primaevus** (Lea) and many others which have not yet been described. According to Mr. C. W. Unger, of Pottsville, who has made numerous collections and whose private museum the writer has been permitted to inspect, there are about 30 different species in the Pottsville territory. In passing southwestward toward the region of distinctly marine seas, it appears that all vestiges of these creatures have disappeared, being replaced by marine invertebrates of which there are apparently none at Pottsville and Mauch Chunk.

Plant remains in the Mauch Chunk of the three counties are fairly numerous and some are well enough preserved for identification, being found partly in the sandstones, partly in the roof shales of the coals, and partly in the greenish and sandy shales that frequently occur, there being occasional instances where both marine and plant forms are closely associated in the same beds. Several good collections of these fossil plants were obtained, the work having been largely done during a week's visit to the territory by Dr. David White of the United States Geological Survey, with the assistance of Paul H. Price and the writer. Dr. White has consented to report on these collections and his discussions will be found in Chapter XVII.

In Chapter XVII, also, will be found a complete list of all fossil collections.

CORRELATION, MAUCH CHUNK SERIES.

In the general section at the beginning of this Chapter the relationship of the Bluestone, Princeton, Hinton, and Bluefield Groups to the Mauch Chunk Series of northeastern Pennsylvania has already been fully indicated, their status being apparently that of subdivisions of this earlier and less detailed grouping. From Mauch Chunk southeastward to central West Virginia these beds have almost entirely been called Mauch Chunk (No. XI of the earlier Rogers classification), the name of "Canaan" and perhaps a few other titles

having been locally employed. From southern West Virginia northeastward the four major groups may be traced approximately to the head of the Greenbrier River but northeast of this valley the series thins to about 800 feet, most of the limestones and other fossiliferous horizons disappear, and the sandstones partly vanish and partly assume a monotonously similar texture of reddish-brown or green so that the southern groupings become indistinct and many of the individual ledges unrecognizable. Across the narrow territory of Maryland the same condition prevails, but in Pennsylvania the series again thickens so that at Pottsville, Tamaqua, and Mauch Chunk it has almost regained its southern West Virginia maximum. After a critical study of the series at these northern localities the writer has noted two large and distinct sandstones which appear to belong in almost the identical stratigraphic positions of the Princeton and Stony Gap Sandstones of southern West Virginia, there being certain physical characteristics which make the resemblance a remarkable one. If these ledges are indeed identical in the two areas, as the detailed sections to be published in a later volume apparently show, it would seem possible that the identity of most of the beds in the intervening territory of thin Mauch Chunk sediments may be finally determined by patient study. Agreement that the two sandstones named actually recur at Pottsville and Mauch Chunk would permit certain other deductions, or hypotheses at least, to be advanced on the paleogeography of Appalachia. Such speculations must naturally be deferred, however, until the data can be fully presented.

Southwestward and westward from southern West Virginia the relationships are more complicated but in the main are quite definite. In southwest Virginia certain of the upper Mississippian beds were named the Pennington Shale by Campbell[6] at Big Stone Gap where they are well exposed, the thickness of the Pennington being recorded as 1,025 feet. From Bluefield to Big Stone Gap these rocks may be traced without serious difficulty, since there are some very good intermediate exposures; and it is quite apparent that at Big

[6]M. R. Campbell, Bull. 111, U. S. Geol. Survey, p. 37; 1893.

Stone Gap the basal member of the Pennington in the Southern Railway tunnel is the Stony Gap Sandstone of Mercer County. Above it occurs a further remnant of the Hinton Group followed by the Princeton Conglomerate and above the Princeton there are nearly 600 feet of shales and sandstone that represent the major portion of the Bluestone Group.

The calcareous shales and limestones coming below and southeast of the sandstone at the tunnel are described as the Newman Formation by Campbell and this has generally been regarded as closely equivalent to the West Virginia Greenbrier. In reality the top of the Greenbrier comes 234 feet (stratigraphic measurement) below the tunnel sandstone, its upper (Alderson) member being quite typical and unmistakable, and the 234 feet of intervening shales, limestones, and weakly bedded sandstones represent all that is left of the Bluefield Group, there being several members which may be identified with the minor subdivisions of Mercer County.

At Cumberland Gap the Mauch Chunk Series has thinned to only 170 feet, its sole recognizable element being the Stony Gap Sandstone which divides it, and the portion below the Stony Gap being almost wholly concealed. At Pineville, Kentucky, the series has further thinned to 90 feet, the fragmentary exposures visible consisting of a nondescript shale. West of Pineville across Kentucky, Butts[1] indicates that the Pennington remains quite thin and almost insignificant but in the extreme western part of the State and in southern Illinois it is recorded as becoming much thicker. Here it is no longer assigned to the Pennington but is known as the Chester of the early Illinois classification. The base of the southern West Virginia Mauch Chunk is quite plain in the sections, however, since the Glen Dean Limestone which is the upper (Alderson) member of the West Virginia Greenbrier has been traced across Kentucky and is easily followed through southwest Virginia to the West Virginia line.

[1]Chas. Butts, Mississippian Series of Eastern Kentucky, 1922; and Mississippian Series in Western Kentucky, 1918; Ky. Geol. Survey.

Taking the Glen Dean-Tar Springs contact as the Greenbrier-Mauch Chunk boundary, which appears to be the case without much doubt, it is evident from the graphic sections of Butts that the Mauch Chunk is represented by 480 feet of sediments. The Chester, on the other hand, has 920 feet of beds definitely assigned to it and 246 feet more are indicated as having a disputed grouping, being assigned to the Chester by some geologists and to the underlying Meramec by others. The merits of this disputed grouping are not pertinent to the present discussion, but it is quite evident that there are 440 feet of admittedly Chester beds coming below the top of Glen Dean and therefore the same interval below the base of the Mauch Chunk, making it quite apparent that the Chester contains at least 440 feet of older beds than the Mauch Chunk.

Taking up now the minor subdivisions of the Mauch Chunk and Chester and considering them in the light of their physical and paleontologic characteristics, it is quite probable that the Edray Sandstone is closely parallel to the Tar Springs Sandstone and there is almost no doubt that the Lillydale Shale is of Menard age since it contains **Sulcatopinna**, a fossil that is largely confined to the Menard and immediately superjacent beds, and there is only a small doubt that the Glenray Limestone is also of Menard age. Higher up in the column the Webster Springs Sandstone appears to correspond closely to the Palestine Sandstone; and the Reynolds Limestone, Ada Shale, and Talcott Shale have so much in common with the Clore Formation that they appear to be its counterpart. If these correlations be accepted it then becomes apparent that the top of the Talcott Shale is the upper boundary of the typical Illinois Chester as defined in the Report cited on Western Kentucky and approximately 3,075 feet of the Mauch Chunk is entirely unrepresented in that region.

Farther north in Missouri, Illinois, and Iowa all the beds that represent the eastern Mauch Chunk appear to have been included in the various local subdivisions of the Chester, but it is hardly pertinent to the present Report to attempt an analysis of the relationships in more detail.

In Tennessee most of the early folios have included the beds of Mauch Chunk age in the Bangor Limestone, describing them as shaly members of this group. The main body of the Bangor, however, is of Greenbrier and older age, so that the Mauch Chunk is only a part of the formation. In later years the Mauch Chunk beds have been described as the Pennington but detailed reports are lacking so that comparisons are not readily made. A recent, but still unpublished, section measured by the writer at Daisy, Hamilton County, Tennessee, where these beds are very well exposed, records 240 feet of Mauch Chunk, but the full thickness is not exposed since the basal beds are below drainage. Another unpublished section at Lookout Mountain just west of Chattanooga reveals 515 feet of Mauch Chunk, the full thickness being high above drainage. On the Dixie Highway southeast of Monteagle a measurement of these beds in company with Mr. Wilbur A. Nelson, State Geologist of Tennessee, shows a thickness of 290 feet; and at Sewanee, Franklin County, farther west along the same highway, another section measured with Mr. Nelson records 230 feet. In all these sections, which it is hoped to publish in detail in a later volume, several members of the Bluefield Group may be readily recognized and some members of the Hinton Group, also, appear to be present.

DESCRIPTION OF MEMBERS, BLUESTONE GROUP OF MAUCH CHUNK SERIES.

It has already been mentioned that exposures in the upper 200 feet of the Bluestone Group are so fragmentary and uncertain that no detailed subdivision of this portion of the group into members appears advisable. In the Pride Section, page 214, there are 108 feet of these rocks in the top of Bent Mountain and they consist of greenish-brown boulders and red, green, and sandy shale but they are too much weathered to recognize the bedding. The remaining 600 feet of the group are exposed at various localities and have been subdivided with a fair degree of certainty. All of the members of this group are named and described for the first time in this Re-

port, the adjective "new" being appended in parentheses to indicate this fact.

BENT SANDSTONE.

The **Bent Sandstone** (new) is a greenish-brown, micaceous, flaggy or shaly ledge, usually varying from 40 to 60 feet in thickness. At its type locality, on Bent Mountain, Mercer County, 1.2 miles southeast of Pride, it is greenish-brown, flaggy, and fine-grained, with a thickness of 55 feet, the elevation of its base being 2910′ B., as recorded in the Pride Section, page 214, and the interval from the top of the mountain to the top of this sandstone being 108 feet. This exposure may be reached readily by the trail which ascends the mountain from the State road south of Pride.

In Mercer County, also, this member is visible in the top of Big Ridge south of Princeton, as recorded in the Stony Gap Section in Chapter V, being 70 feet thick and consisting of two benches separated by 20 feet of shale. Farther east it is visible in a field just east of a road summit 0.7 mile south of Stinson School and 2.1 miles southeast of Princeton, being massive and having an elevation of 2270′ B.

In Monroe County the horizon of this ledge is everywhere above the topography but in northern Summers it is present, being noted in Chapter V in the sections for Green Sulphur Springs, New Richmond, and Ramp; and just across the line in Fayette County it appears to be the massive ledge which holds the 2770-foot bench mark one-fourth mile west of Springdale; and it is also visible in the road along the head of Buffalo Creek 1.3 miles southeast of Springdale, being 50 feet thick, massive, and having an elevation of 2705′ B.

So far as known this ledge has not been quarried and in general it does not appear suitable for building purposes but there may be a few local outcrops where it would be fit for local use.

UPPER BENT SHALE.

The **Upper Bent Shale** (new) is the member lying immediately beneath the Bent Sandstone, being sometimes red and

variegated and sometimes black and fissile, with marine fossils, its thickness varying from 20 to 40 feet. Its type locality is on Bent Mountain, Mercer County, 1.2 miles southeast of Pride, being there red and green and 55 feet thick, as recorded in the Pride Section, page 214. In Summers County this shale is recorded in Chapter V in the New Richmond Section at elevation 2710′ B., being 10 feet thick, greenish-yellow, and sandy. In Tazewell County, Virginia, on the waters of Mud Fork it carries marine fossils, both ostracods and pelecypods.

BENT LIMESTONE.

The **Bent Limestone** (new) is a thin and lenticular horizon, named from its association with the Upper Bent Shale. Its presence was not noted in any of the three counties under study but in Tazewell County, Virginia, it was observed on a cross-road which passes from Bailey Station northwestward to Mud Fork of Bluestone River, the outcrop being on the Mud Fork side of the ridge and about one mile from the station. Here it lies just between the Upper Bent and Lower Bent Shales, being two inches thick but carrying ostracods.

LOWER BENT SHALE.

The **Lower Bent Shale** (new) is a green, argillaceous, and fissile deposit, carrying marine fossils, there being both pelecypods and ostracods. It was not observed in the three counties but is visible in Tazewell County, Virginia, at the locality above named for the Bent Limestone, where it is six feet thick.

HUNT COAL.

The **Hunt Coal** (new) is a thin and lenticular bed but is of much interest because it is apparently the uppermost coal in the Bluestone Group. Its type locality is at **Coal Exposure No. 753 on Map II,** along a cross-road between North and South Forks of Brush Creek just west of Hunt School on the North Fork side of the dividing ridge. Here it occurs at elevation 2625′ B., being only eight inches thick. In the same

county it is again visible at **Coal Exposure No. 754 on Map II** along a road which ascends Big Ridge 0.3 mile north of Billie at elevation 2735′ B., its outcrop consisting of dark shale and the blossom of coal. This outcrop is mentioned in the Stony Gap Section in Chapter V where its stratigraphic associations are exhibited. Elsewhere in the three counties this coal was not observed, but in Wise County, Virginia, near Big Stone Gap, Campbell long ago noted a thin, cannelly coal in the top of the Newman (Mauch Chunk), which appears to be ver. near the position of the Hunt Coal. At this locality the sandy shales above it carry marine fossils, including pelecypods and brachiopods **(Lingula)**, and may well represent the Lower Bent Shale.

HUNT SANDSTONE.

The **Hunt Sandstone** (new) is a shaly ledge coming only a few feet below the Hunt Coal, as noted in the Stony Gap Section, page 196, the exposure being in Mercer County on the north side of Big Ridge about three-fourths mile south of Belcher School, where it is 15 feet thick. It was not otherwise noted but may doubtless be found at various points along the Hurricane Ridge Syncline.

HUNT SHALE.

The **Hunt Shale** (new) is a red and variegated deposit, 35 feet thick and visible just below the Hunt Sandstone on the north side of Big Ridge, Mercer County, at the locality above described for the Hunt Sandstone, being recorded in the Stony Gap Section. Elsewhere it was not noted but it can probably be found generally along the Hurricane Ridge Syncline.

BRATTON SANDSTONE.

The **Bratton Sandstone** (new) is a green, flaggy or massive, fine-grained ledge, having its type locality in Mercer County on the road from Princeton southward to the top of Big Ridge near the extreme head of Bratton Branch of Brush

Creek, as recorded in the Stony Gap Section, page 196. Here it is only five feet thick, but on Bent Mountain in the same county it is 20 feet thick and massive, as recorded in the Pride Section in Chapter V.

BRATTON SHALE.

The **Bratton Shale** (new) is named from its association with the Bratton Sandstone, being exposed just beneath the latter ledge at the locality above described near the head of Bratton Branch and being recorded in the Stony Gap Section. Here it is red and 35 feet thick, but in the Pride Section of Chapter V it is recorded as visible on Bent Mountain with a thickness of 30 feet and a greenish-brown color and sandy texture.

UPPER BELCHER SANDSTONE.

The **Upper Belcher Sandstone** (new) is a greenish-gray, massive, and medium-coarse ledge, having its type locality in Mercer County on the road from Princeton southward to Big Ridge just north of Belcher School from which its name is derived. Here it is 15 feet thick, as recorded in the Stony Gap Section, page 196, there being a second exposure one-half mile south of the school. In the Pride Section of Chapter V it is again recorded as occurring on Bent Mountain where it is 40 feet thick, green, and shaly. On a branch of Twelve-mile Creek, Mercer County, it is visible 0.6 mile west of Rocky Hollow School at elevation 2330′ B., being 40 feet thick, massive, coarse, and brecciated, with imbedded shale and iron particles at the base. At the northern end of the Virginian Railway tunnel 1.7 miles south of Princeton Station it is visible in the cut, being massive and coarse. In Summers County it is noted in the sections for Green Sulphur Springs, New Richmond, Ramp, and Hinton, all published in Chapter V. So far as known this ledge has not been quarried but it could probably be used for local masonry with satisfaction if so desired.

UPPER BELCHER SHALE.

The **Upper Belcher Shale** (new) is a generally red deposit, with a thickness of 15 to 20 feet, and carrying occasional marine fossils. At its type locality on the Princeton-Big Ridge road just north of Belcher School, Mercer County, as noted in the Stony Gap Section, page 196, it is 30 feet thick, with a two-foot bed of carbonaceous fire clay near the middle that is suggestive of a coal horizon, but apparently none occurs.

In Summers County this shale is recorded in the sections for Green Sulphur Springs, New Richmond, Ramp, and Hinton, all published in Chapter V. At these localities it is generally plain red shale. On Mud Fork, Tazewell County, Virginia, north of Bailey Station, it carries both plant and marine fossils, there being roots and pelecypods.

LOWER BELCHER SANDSTONE.

The **Lower Belcher Sandstone** (new) is a greenish-gray, flaggy, and micaceous or massive ledge, coming just below the Upper Belcher Shale and having its type locality on the Princeton-Big Ridge road slightly north of Belcher School, its elevation being 2585′ B. Here it is massive and 40 feet thick but split into two benches by 5 feet of red and sandy shale, as recorded in the Stony Gap Section, page 196. In the same county it is again visible along the Virginian Railway 1.4 miles south of Princeton Station and 0.2 mile north of the tunnel, being a massive ledge but not fully exposed, the elevation of its top being 2480′ B.

In Summers County it is recorded in the sections for Green Sulphur Springs, New Richmond, and Ramp, all of which are published in Chapter V. At these localities it varies from 35 to 45 feet in thickness, being usually green and sometimes shaly. So far as known it has not been quarried and it seldom appears to be durable enough for good building stone.

LOWER BELCHER SHALE.

The **Lower Belcher Shale** (new) is a red or sandy deposit coming just below the Lower Belcher Sandstone and having

its type locality along the Princeton-Big Ridge road slightly north of Belcher School, as recorded in the Stony Gap Section. Here it is red and 15 feet thick, but along the Bluefield-Princeton road on the north side of Brush Creek one mile northeast of Bridge School an exposure that appears to be this shale is dark, sandy, and micaceous, and carries marine fossils. At this locality Dr. Girty and the writer made a collection (**Lot 206**), the fossils being mostly pelecypods as reported in more detail by Dr. Girty in Chapter XVIII. In Summers County it is recorded in the sections for Green Sulphur Springs and New Richmond, as published in Chapter V.

UPPER MUD SANDSTONE.

The **Upper Mud Sandstone** (new) is a brown, shaly, and micaceous ledge belonging just below the Lower Belcher Shale and having a thickness of only about 5 feet. Its type locality is on Mud Fork of Bluestone River in Tazewell County, Virginia, along a cross-road which passes from Bailey Station northward to Mud Fork and about one mile north of the station. Here it comes 75 feet above the top of the Glady Fork Sandstone. In Mercer County it is noted in the Stony Gap Section, published in Chapter V.

UPPER MUD SHALE.

The **Upper Mud Shale** (new) is a deposit of almost purely red material coming between the Upper and Lower Mud Sandstones and having its type locality in Tazewell County, Virginia, at the locality above named for the Upper Mud Sandstone, its thickness at this point being 50 feet. In Mercer County it is noted in the Stony Gap Section, being 50 feet thick and quite red. It could doubtless be identified at numerous other localities in the three counties if so desired.

LOWER MUD SANDSTONE.

The **Lower Mud Sandstone** (new) is a thin, greenish-gray or brown ledge, coming between the Upper Mud and Lower Mud Shales and being the first sandstone horizon above the

PLATE XVII.—Glenray Limestone (type locality) capped by Webster Springs Sandstone on west side of Greenbrier River just opposite Glenray and just north of Griffith Creek, Summers County. Foreground is Greenbrier River. See Glenray Section. (Photo. by Palmer & Fowler).

top of the massive and persistent Glady Fork Sandstone. Its type locality is in Tazewell County, Virginia, at the locality above named for the Upper Mud Sandstone. It is not identified in any of the sections of the three counties and its presence in them is therefore in doubt.

LOWER MUD SHALE.

The **Lower Mud Shale** (new) is a red and variegated or dark-green shale, lying between the Lower Mud and Glady Fork Sandstones and having its type locality at the point above named for the Upper Mud Sandstone. In Mercer County it is recorded in the section for Stony Gap, as published in Chapter V, being there readily distinguishable from the Upper Mud Shale by its different color and texture, although the intermediate Lower Mud Sandstone is absent. On Mud Fork its thickness is 20 feet and in the Stony Gap Section it is 40 feet. In Summers County it is noted in the Alderson Section, as published in Chapter V, being 28 feet thick, red and variegated.

GLADY FORK SANDSTONE.

The **Glady Fork Sandstone** (new) is a greenish-brown, coarse, massive and quite persistent ledge, being the first stratum of this character that is generally found above the Princeton Conglomerate, and having a thickness of 25 to 40 feet. Its type locality is in Mercer County along the Bluefield-Princeton road, being conspicuous in the end of the ridge between Brush Creek and Glady Fork of the same just southeast of Princeton. Here it is 30 to 40 feet above drainage, making a bold ledge, and a little farther southwest up Brush Creek it descends to the level of the highway. At **Fossil Lot 236 on Map II,** on Brush Creek 1½ miles southwest of Princeton, it is a conspicuous ledge at the roadside, there being a few lentils of shale and coal spars and many well-preserved specimens of plant fossils, **Bornia (Asterocalamites) radiata.** Here Dr. David White, Mr. Price, and the writer made a collection which will be discussed by Dr. White in Chapter XVII. From this locality southwestward toward

Glenwood it is conspicuous at several points along the road and in the slope of the hill north of Brush Creek.

In Mercer County, also, it is recorded in the Stony Gap Section of Chapter V, its interval being approximately 150 feet above the Princeton Conglomerate from which it is separated by thick shales.

In Summers County it is noted in the Green Sulphur Springs Section of Chapter V as 55 feet thick and shaly, and in that for Alderson as 11 feet thick and shaly. In the same county it is visible along the Bluefield-Hinton road on Tallery Mountain at **Fossil Lot 240,** as later detailed, near the foot of Davy Knob and 1.1 miles northeast of Pipestem. North of Hinton it is often prominent, being visible in Grimmett Bench of Keeney Mountain 1.2 miles northeast of Pleasant View School, its top having an elevation of 2690′ B. It also appears to be the conspicuous shaly cliff around the south end of Red Spring Mountain coming about 100 feet above the top of the Princeton Conglomerate. A little farther southeast it is visible along a private road 0.1 mile east of Karn School, its top having an elevation of 3050′ B. and coming 60 feet above the top of the Princeton.

So far as known this ledge has not been quarried but at various localities it could be split into massive blocks that would be serviceable in masonry structures and the effect of its brown color would be pleasing.

PIPESTEM SHALE.

The **Pipestem Shale** (new) is a bed which immediately underlies the Glady Fork Sandstone, being usually brown or gray and sandy, with streaks of sandstone, and carrying both plant and marine fossils, and having a thickness of 30 to 45 feet. Its type locality is in Summers County, the following local measurement indicating its nature and stratigraphic associations:

Local Measurement at Fossil Lot 240.

Pipestem District, Summers County; in Tallery Mountain road near foot of Davy Knob and 1.1 miles northeast of Pipestem; gentle northwest dip; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluestone Group (60′)		
1. **Sandstone, Glady Fork,** shaly	10	10
2. **Shale, Pipestem** (type locality), sandy, with marine fossils. Collection from plant fossils (see **Lot 240**)	10	20
3. **Coal, Pipestem,** streak (2430′ B.) **(Exposure No. 758 on Map VI)**	..	20
4. Fire clay and shale to glade at foot of hill	40	60

The collection of plants at the above locality, made by Dr. David White, Mr. Price, and the writer, will be listed and discussed by Dr. White in Chapter XVII.

In Summers County, also, this shale is noted in the Green Sulphur Springs Section of Chapter V, being 35 feet thick and dark.

In Mercer County the following local measurement indicates its nature and gives its stratigraphic associations:

Local Measurement at Fossil Lot 205.

Beaver Pond District, Mercer County; along Bluefield-Princeton road on north side of Brush Creek, 1 mile northeast of Bridge School and 1.9 miles southwest of Princeton Station; gentle southeast dip; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluestone Group (80′)		
1. **Sandstone, Glady Fork** (type locality), greenish-brown, massive, coarse	50	50
2. **Shale, Pipestem,** dark, sandy, weathering into pencil forms (2425′ B.); contains marine fossils, small pelecypods (see **Lot 205**)	30	80
3. Concealed across highway and trolley to Brush Creek	..	..

The above collection, made by Dr. George H. Girty and the writer, will be listed in detail by Dr. Girty in Chapter XVIII. In the Stony Gap Section of Mercer County the stratigraphic intervals of the Pipestem Shale to other members may be more fully noted.

PIPESTEM COAL.

The **Pipestem Coal** (new) is a thin and lenticular horizon, usually less than one foot thick, which occurs between, and when present separates, the Pipestem and Pride Shales. In Mercer County it is visible at a few points, as detailed below:

Coal Exposure—No. 755 on Map II.

Along the Bluefield-Bramwell road on a branch of Bluestone River 0.7 mile south of Brush Fork village; **Pipestem Coal**; elevation, 2475′ B.

	Ft.	In.
Sandstone, shaly	10	0
Coal	0	2
Shale, sandy (dip, north, 10°)	..	..

Coal Exposure—No. 756 on Map II.

On the west side of a branch of Twelvemile Creek 1.5 miles north of Ingleside; **Pipestem Coal**; elevation, 2215′ B.

	Ft.	In.
Sandstone, Glady Fork, massive cliff	20	0
Shale, Pipestem, very sandy, ferruginous	15	0
Coal, Pipestem	0	2
Fire clay shale, yellow, ferruginous, and calcareous, to road	20	0

At **Coal Exposure No. 757 on Map II,** along the Princeton-Narrows road at the head of Fivemile Creek 0.8 mile southwest of Johnson School, there is a streak of dark, coaly shale coming between beds of sandy shale at elevation 2560′ B. that appears to represent the Pipestem Coal, although its position relative to the Princeton or any other bedded sandstone is not exhibited.

In Summers County it is exhibited at **Coal Exposure No. 758 on Map VI** in the Bluefield-Hinton road along Tallery Mountain 1.1 miles northeast of Pipestem village, being there only a streak as noted in the description of Fossil Lot 240, pages 322-3.

In the same county it is visible at **Coal Exposure No. 759 on Map VI** in the Bluefield-Hinton road along Tallery Mountain 0.3 mile east of Pipestem Knob and 2.4 miles south of Pipestem village. Here it is 0′ 3″ thick and bedded in sandy shale at elevation 2610′ B., this being designated as its type locality.

The above exposures, all of which are thin and worthless, do not favor the belief that any coal of value will be found at the Pipestem horizon.

PRIDE SHALE

The **Pride Shale** (new) is a greenish-brown, sandy, and fissile deposit, coming between the Pipestem Coal and Princeton Conglomerate and being the basal member of the Bluestone Group. This is a very persistent and easily recognized horizon on account of its uniformly dark color and its weathering or exfoliating into long, pencil-like forms. Its thickness appears to vary from 70 to 150 feet and it is of wide areal extent, being found far up the Greenbrier Valley in West Virginia and also southwestward in Virginia. Its type locality is designated at the base of Bent Mountain, just south of Pride, Mercer County, where, as detailed in the Pride Section, page 214, there is an exposure of 40 feet followed by an underlying concealed interval of 35 feet more which evidently belongs to it. Here, at **Fossil Lot 204 on Map II,** the writer noted a few small pelecypods but at a subsequent visit in company with Dr. Girty these bivalves could not be found and only a few uncertain organic fragments, one of which the writer took to be part of an **Orthoceras,** were noted. In a preliminary communication Dr. Girty, however, reports that there is nothing determinable in the collection.

In Mercer County, also, this shale is recorded in the Stony Gap Section of Chapter V as 100 feet thick, but this thickness is taken from a bore-hole record, the outcrop being covered. In the adjoining area of Tazewell County, Virginia, it is well-exposed in the cuts of the Norfolk & Western Railway on the north side of Bluestone River about one mile southeast of Falls Mills.

In Summers County the Pride Shale is recorded in Chapter V in the sections for Green Sulphur Springs, New Richmond, Ramp, Hinton, and Alderson, but in this direction it has decreased in thickness, the exposures varying from 10 to 57 feet.

DESCRIPTION OF MEMBERS, PRINCETON CONGLOMERATE OF MAUCH CHUNK SERIES.

PRINCETON SANDSTONE.

The **Princeton Sandstone,** or **Princeton Conglomerate,** of Campbell,[8] is the single member of the Princeton Group of the Mauch Chunk Series. As originally defined by Campbell its type locality is in the vicinity of Princeton, Mercer County, there being no cross-section of its immediate stratagraphic associations although a good description is afforded. Its character in general is that of a gray, coarse, massive, conglomerate, varying in thickness from 20 to 50 feet. It is usually extremely hard and nearly always contains quartz pebbles scattered throughout the mass and frequently has impure limestone pebbles toward the base. A very good view of this member is now afforded in the deep cut of the Virginian Railway just north of the station at Princeton where the following local measurement was obtained:

Local Measurement at Fossil Lot 239.

East River District, Mercer County; in Virginian Railway cut north of Princeton Station; gentle southward dip; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Princeton Conglomerate (25′)			
1.	**Sandstone, Princeton,** brown, massive, pebbly....	25	25
Mauch Chunk Series—Hinton Group (28′)			
2.	**Shale, Terry,** sandy, with plant fossils.....	15	40
3.	**Coal** streak.....		
4.	Fire clay shale, with plant fossils..... 5′ 0″	**Pluto Coal** (2400′ B.). (Exposure No. 761 on Map II). 5½	45½
5.	**Coal** 0 4		
6.	Shale, gray.....	2½	48
7.	Sandstone, shaly, to grade.....	5	53

Collection of plant fossils from Nos. 2 and 4 of section (see **Lot 239** in Chapter XVIII).

In the above section plant fossils were collected by Dr. David White, Mr. Price, and the writer at **Fossil Lot 239.** This collection will be mentioned later under the description of the Terry Shale.

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[8] M. R. Campbell, Pocahontas Folio, No. 26, U. S. Geol. Survey; 1896.

In the Princeton Sandstone itself no marine fossils have been found but there are occasional poorly preserved specimens of plants. In Mercer County the occurrence of this ledge is noted in the Stony Gap and Pride Sections of Chapter V, and in Tazewell County, Virginia, it is noted in that for Falls Mills. The sandstone is conspicuous along Bluestone River on the northwestern slope of the Abbs Valley Anticline where at times it assumes a nearly vertical position, one of these prominent reefs being on the south side of the river, 0.5 mile southwest of Flipping, where it is very pebbly and dips northwestward at an angle of approximately 70 degrees. In the road just southeast of Kegley it is again visible, being pebbly and dipping northwestward at an angle of 15 degrees, and just southeast of Gardner it is again prominent the dip being more moderate.

On the southeastern limb of the Abbs Valley Anticline it makes an almost continuous and visible outcrop starting at Falls Mills, Virginia, where it crosses Bluestone River just south of the railroad station and then passes northeastward up Brushy Fork and on to Princeton by way of North Fork and Glady Fork of Brush Creek.

South of the Hurricane Ridge Syncline it crosses Bluestone River a little more than one mile northwest of Graham (now Bluefield, Virginia) where it is double-bedded with a streak of shale in the middle as exhibited in the following local measurement:

Local Measurement at Fossil Lots 126 and 237.

Tazewell County, Virginia; in Clear Fork District, at west end of highway and railroad bridge across Bluestone River 1.3 miles northwest of Graham; dip, northwest 12°; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluestone Group ( )		
1. Shale, variegated.....	..	..
Mauch Chunk Series—Princeton Conglomerate (40′)		
2. **Sandstone, Princeton,** containing shaly streak near middle; upper portion massive and hard; lower bench massive and hard with quartz pebbles throughout and with limestone conglomerate at base; contains plant fossils (see **Lot 237**).....	40	40

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (20′)		
3. **Shale, Terry,** hard, sandy, with **coaly** streak and with plant fossils (see **Lot 237**).....	10	50
4. Shale, **Terry Limestone** horizon, ferruginous and containing numerous marine fossils, chiefly brachiopods, also pelecypods, trilobites, and bryozoa (see **Lot 126**).....	1	51
5. **Shale, Pluto,** dark, sandy, to road (2355′ B.)....	9	60

At the above locality plants were collected by Dr. David White, Mr. Price, and the writer at **Fossil Lot 237,** and marine fossils were collected by Dr. George H. Girty and the writer at **Fossil Lot 126,** as will be later mentioned under the descriptions of the members in which they occur. Some of these plants, however, were found in the base of the Princeton, the specimens from this and the Terry Shale being combined in one collection, the discussion of which by Dr. White will be found in Chapter XVII.

From this locality northeastward the outcrop of the Princeton Sandstone passes northeastward up a branch of Bluestone River and down the South Fork of Brush Creek, crossing the Bluefield-Princeton road about one-third mile northeast of Stony Gap where it is nearly vertical but worn off so completely as to be inconspicuous. Farther on, however, it makes a prominent reef near the Robin's Rest Tea Room and at other points on the northern slope of Stony Ridge, there being a series of shoulders and sharp points upheld by the formation nearly all the way from Bluestone River to Twelvemile Creek. On this latter creek it makes a hard, coarse, massive cliff, 40 feet thick, at elevation 2120′ B., one mile north of Ingleside. Farther east it is visible on a branch of Fivemile Creek east of the Princeton-Narrows road, 1.6 miles northwest of White School, being pebbly and 20 feet thick at elevation 2450′ B. Farther southeastward on the same road it was noted at **Fossil Lot 238,** as will be later exhibited under the description of the Terry Shale, this locality being almost in the axis of the Hurricane Ridge Syncline. Its presence is again shown in the description of **Fossil Lots 210 and 211** in the Falls Mills and Upper Fivemile Shales, respectively, the locality being slightly farther east on the north side of Fivemile Creek.

This sandstone also forms part of the high plateau east of Princeton and east of Johnson School but in that direction it rises rapidly eastward and finally overshoots the topography in the vicinity of Scratchgravel School west of New River, there being visible outcrops in the vicinity of Pennington School south of Elgood.

In Monroe County the Princeton does not occur, its horizon at all points being above the present topography. In Summers County it is conspicuous at many localities, being noted in Chapter V in the sections for Green Sulphur Springs, New Richmond, Ramp, Hinton, Bellepoint, Bertha, Pence Springs, Alderson, Warford, and Tallery Mountain, its thickness at these exposures varying from 20 to 60 feet. In the northern part of the county it makes a high bench around the north sides of Hump and Gwinn Mountains. On the road which passes from Keeney Knob northwestward for several miles there are numerous exposures, there being an interesting display of breccia in the basal portion of a 35-foot ledge along the private road ascending the ridge west of Patterson Creek, 1.6 miles southwest of Grassy Meadow, at elevation 2910′ B. On Keeney Mountain it usually makes a wide bench on either side of the ridge and upholds the younger deposits of the Bluestone Group but at the southwestern end of the mountain it forms the surface, the later deposits being removed by erosion. On the western side of New River it is conspicuous along the road southeast of Jumping Branch, there being a considerable sloping plateau made mainly by its surface.

In the angle between New and Greenbrier Rivers it is prominent in the northern end of Wolf Creek Mountain where it forms the surface from Sand Spring School for a mile northwestward, and farther south on the same mountain it makes several isolated exposures, one of these being one mile south of Bennett School, another just south of Foster School, and another one-half mile south of Low Gap School at the Government triangulation point. On Tallery Mountain between New and Bluestone Rivers it makes numerous outcrops, being

the principal formation that preserves the tableland of the mountain.

The more detailed occurrence of the Princeton Sandstone may be noted on Maps II and VI where its position has been delineated. Illustrations are afforded in Plates VII and VIII.

So far as known the Princeton has not been quarried and in general it is doubtful whether it could be successfully used for building purposes because of its conglomeratic character and lack of uniformity which would prevent it from being fashioned into building blocks of a uniform size. For rough masonry like retaining walls and other structures of similar kind it has occasionally been used and apparently gives satisfaction.

DESCRIPTION OF MEMBERS, HINTON GROUP OF MAUCH CHUNK SERIES.

In the Hinton Group of the Mauch Chunk Series only a few members have been previously named and described. In the descriptions which follow, an appropriate reference is made in such cases. All others are newly described in this Report, the adjective "new" being added in parentheses to indicate this fact.

TERRY SHALE.

The **Terry Shale** (new) is a greenish-brown, sandy deposit, with occasional lentils of coal and streaks of red shale, coming just below the Princeton Sandstone and having a thickness of 15 to 50 feet and being the highest formation of the Hinton Group. It is named from its association with the Terry Limestone above which it belongs. In Mercer County it is noted in the Pride Section of Chapter V, being reddish-brown and 15 feet thick; and in Tazewell County, Virginia, it is recorded in the Falls Mills Section as 50 feet thick but is there combined with the Pluto Shale, the intermediate members being absent. In Summers County it is noted in the sections for Green Sulphur Springs, New Richmond, and Tallery Mountain.

This shale contains plant fossils, a collection having been made at **Fossil Lot 237 on Map II** on Bluestone River northwest of Graham as already described in a local measurement on pages 327-8. Another collection was made at **Fossil Lot 239 on Map II** just north of the railroad station at Princeton as described in a local measurement on page 326; and a third collection was made on the upper waters of Fivemile Creek as exhibited in the following local measurement:

Local Measurement at Fossil Lot 238.

East River District, Mercer County; in road along branch of Fivemile Creek 1.3 miles northwest of White School and 4.5 miles southeast of Princeton; gentle southward dip; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Princeton Conglomerate (15′)		
1. **Sandstone, Princeton,** massive, pebbly	15	15
Mauch Chunk Series—Hinton Group (21′)		
2. **Coal (0′ 4″)**	0½	15½
3. **Shale, Terry,** sandy (2350′ B.); contains plant fossils at base (see **Lot 238**)	10	25½
4. **Coal (0′ 6″), Pluto? (Exposure No. 762 on Map II)**	0½	26
5. Shale, sandy, to road	10	36

The above collections were made by Dr. David White in company with Mr. Price and the writer and their discussion by Dr. White will be found in Chapter XVII.

TERRY LIMESTONE.

The **Terry Limestone** of Krebs,[9] having its type locality in Raleigh County, where it is described as a gray limestone with marine fossils, appears to occur in Mercer and Summers Counties only as a ferruginous and sandy, but abundantly marine, deposit, which is two feet or less in thickness and frequently absent. Where present, however, it may usually be distinguished with ease from the overlying Terry Shale and from the underlying Pluto Shale on account of its difference in color and texture and its abundant fossil content. In Tazewell County, Virginia, it is well exhibited at **Fossil Lot 126 on Map II,** on the south side of Bluestone River about one

[9]C. E. Krebs, Raleigh Report, W. Va. Geol. Survey, p. 69; 1916.

mile northwest of Graham, as detailed in the local measurement on pages 327-8. Here a collection of marine fossils was made by Dr. Girty and the writer, there being pelecypods, brachiopods, bryozoa, and trilobites, as will be listed and discussed by Dr. Girty in Chapter XVIII.

In Summers County this horizon is noted in the Tallery Mountain Section south of True where it is one foot thick and sandy at elevation 2330′ B., and contains numerous marine fossils, chiefly brachiopods, **Fossil Lot 184 on Map VI** having been collected by Dr. Girty and the writer at this locality as will be later discussed by Dr. Girty in Chapter XVIII. In the Bellepoint Section on Wolf Creek Mountain southeast of Bellepoint, as previously published in Chapter V, this member is noted along with the Pluto Shale as containing marine fossils, chiefly brachiopods and pelecypods, as listed in **Fossil Lot 189 on Map II,** collected by the writer and discussed by Dr. Girty in Chapter XVIII.

PLUTO SHALE.

The **Pluto Shale** of Reger,[10] described as occurring just over the Pluto Coal, is found in Mercer and Summers Counties, being greenish-brown, sandy, slightly ferruginous, fissile, and usually weathering into pencil-like forms and having occasional marine fossils in streaks and zones. Its thickness usually varies from 25 to 40 feet but in the vicinity of Princeton it is apparently quite thin or absent allowing the Terry Shale to rest directly on the coal. In Mercer County it is noted in the Pride Section of Chapter V, being represented by a shaly sandstone 30 feet thick; and in Tazewell County, Virginia, it is recorded as 9 feet thick but not fully exposed, as published in the local measurement at **Fossil Lot 126 on Map II,** page 328. In Summers County it is recorded in the Bellepoint Section on Wolf Creek Mountain southeast of Bellepoint as being a dark, fissile deposit with which is included the Terry Limestone horizon and in which marine fossils occur. **Fossil Lot 189 on Map VI** was collected at this

[10]David B. Reger, Webster Report, W. Va. Geol. Survey, pp. 219-220; 1920.

locality, for the descriptive list of which by Dr. Girty a reference has already been made to Chapter XVIII.

PLUTO COAL.

The **Pluto Coal** of Krebs,[11] having its type locality in Raleigh County, is present in Mercer and Summers but is usually impure, thin, and lenticular and of small value although a few attempts have been made to mine it for local use. Its position is between the Pluto and Lower Pluto Shales and at an interval below the Princeton Sandstone of 15 to 75 feet.

In Mercer County four exposures of the Pluto Coal were noted, as follows:

W. N. Looney Farm Mine—No. 760 on Map II.

On the north side of Glady Fork of Brush Creek 1.3 miles southwest of Princeton Court-house; **Pluto Coal**; elevation, 2435′ B.

	Ft.	In.
Sandstone, Princeton, massive, very pebbly, cliff	20	0
Shale, Terry, brown, sandy, partly concealed, 5′ to	10	0
Coal, thickness concealed by water, reported	1	6

At **Coal Exposure No. 761 on Map II,** located in the deep cut of the Virginian Railway just north of Princeton Station, the seam is divided into two benches by a five-foot streak of fire clay shale, the upper bench being a mere streak while the lower is only 0′ 4″ thick, as detailed under the description of **Fossil Lot 239 on Map II,** page 326.

At **Coal Exposure No. 762 on Map II,** located in the Princeton-Narrows road along a branch of Fivemile Creek 1.3 miles northwest of White School, the coal is again visible, being 0′ 6″ thick, as detailed under the description of **Fossil Lot 238 on Map II,** page 331.

[11] C. E. Krebs, Raleigh Report, W. Va. Geol. Survey, pp. 74 and 635; 1916.

Coal Exposure—No. 763 on Map II.

Along the Princeton-Athens road 1.2 miles southwest of Athens; **Pluto Coal**; elevation, 2685′ B.

	Ft.	In.
Sandstone, mostly coarse, gray boulders....	..	..
Coal	0	10
Sandstone, massive	5	0
Shale, sandy	10	0

The identification of this exposure is subject to some doubt since no pebbles were noted in the overlying sandstone boulders and the ledge which comes just beneath the coal is also an unusual feature.

In Summers County the only point where coaly matter was noted at the Pluto horizon was at the **Coleman Plumley Prospect (No. 764 on Map VI)** on the southeast side of Keeney Mountain 1.6 miles east of Hinton at elevation 2405′ B., where the visible outcrop in a spring consists of 0′ 9″ of coaly slate, as noted in the Hinton Section, page 246.

From the above exposures it is apparent that little coal of any value may be expected at the Pluto stage.

PLUTO LIMESTONE.

The **Pluto Limestone** (new) is a shaly and impure, calcareous horizon belonging just below the Pluto Coal and named from its association with that horizon, its thickness being two feet or less and its presence in the rock column only occasional, but there being marine fossils at some exposures. In Mercer County it was not noted, but in Summers it is recorded as two feet thick and yellowish-green in the Green Sulphur Springs Section of Chapter V, and in the Tallery Mountain Section of the same Chapter it is noted as shaly, two feet thick, and containing marine fossils among which are crinoids, brachiopods, and gastropods. In this section it comes 40 feet below the Terry Limestone, the presence of which is there accounted for by an abundantly marine, ferruginous zone, and leaving little doubt as to the separate existence of the two beds.

LOWER PLUTO SHALE.

The **Lower Pluto Shale** (new) is a greenish-brown, sandy deposit, with occasional red beds and streaks of sandstone, occupying the interval between the Pluto Limestone and Falls Mills Sandstone. Its thickness varies from 50 to 80 feet and it frequently contains marine fossils, mostly pelecypods, among which **Myalina** is a common genus, and it also carries occasional plant fossils. In Tazewell County, Virginia, it is recorded in the Falls Mills Section of Chapter V, being 80 feet thick and sandy. In Mercer County it is noted as 35 feet thick and red in the Pride Section of the same Chapter. In Summers County its presence and stratigraphic associations are exhibited in the Alderson, Bellepoint, Bertha, Hinton, Pence Springs, Tallery Mountain, and Warford Sections of the same Chapter. In the Bellepoint Section, page 249, it contains three zones of marine fossils from which **Fossil Lots Nos. 190, 191, and 192 on Map VI** were collected, the lists of which, as identified by Dr. Girty, will be found in Chapter XVIII. Near the base of the formation at this locality there is also a streak of gray fire clay shale with plant fossils, indicating an incipient coal horizon which never appears to have reached the actual carbonaceous stage.

FALLS MILLS SANDSTONE.

The **Falls Mills Sandstone** (new) is a greenish-gray ledge, usually massive and fairly coarse but sometimes shaly, its thickness varying from 25 to 50 feet. At most localities it is the first sandstone of any consequence below the Princeton Conglomerate, the interval of its base below that horizon varying from 150 to 225 feet. Its type locality is in the edge of Tazewell County, Virginia, just west of Falls Mills Station where it makes a conspicuous reef or natural dam across Bluestone River that has long been utilized for power at the old mill from which the village derives it name. Here, as recorded in the Falls Mills Section, page 190, it is green, flaggy, and 40 feet thick.

In Mercer County it is noted in the Stony Gap, Athens, and Pride Sections of Chapter V, being a massive and prominent ledge at the latter locality. In the region just east of Princeton it is visible at several points along the Princeton-Athens road where this highway passes up Daves Fork of Brush Creek, being also present in the road at Barber School and along the old ridge road to the westward. At Athens it is the principal support of the plateau on which the town is built, being only a few feet below the surface. Farther east it appears to be this sandstone which forms the plateau along the Plymouth-East River District line for several miles west of Elgood; and farther south on the waters of Fivemile Creek it is 50 feet thick and massive at elevation 2260′ B., in an abandoned road 0.8 mile north of White School and just south of the Hurricane Ridge Syncline.

In Summers County it is noted in the sections for Alderson, Bellepoint, Bertha, Green Sulphur Springs, Hinton, Pence Springs, and Tallery Mountain, all published in Chapter V, its thickness varying from 5 to 70 feet. In the northern end of the county it is visible along the Meadow Creek road one mile south of Meadowbridge, at elevation 2270′ B., being 25 feet thick and massive, and on the head of Mill Creek 0.3 mile southeast of Lane School and 1.4 miles northwest of Elton it is a massive, green, fine-grained cliff, 30 feet thick, at elevation 2245′ B.

So far as known the Falls Mills Sandstone has not been quarried in either Mercer or Summers Counties, but at various exposures it appears to be sufficiently durable and uniform to be used for construction purposes if so desired, and its general texture is such that it would not be displeasing to the eye.

FALLS MILLS SHALE.

The **Falls Mills Shale** (new) is a calcareous or red, sandy, and variegated deposit belonging just below the Falls Mills Sandstone and having a thickness of 25 to 40 feet. At some localities it contains marine fossils, pelecypods, chiefly of the

PLATE XVIII.—Looking south up Crooked Creek 1½ miles west of Brick Church, Monroe County. Grassy field in foreground is Bluefield, followed by Greenbrier and Maccrady in cleared slope. First wooded ridge is Little Mountain with Poeono on north side. Low wooded hills in middle are Chemung and Portage. All these slightly overturned and now dipping south. Peters Mountain in extreme background capped by White Medina followed below by Red Medina, and Ordovician shales and limestone in natural bedding, dipping south. (Photo. by Palmer & Fowler).

genus **Myalina**, and ostracods being common. Its type locality is in the Norfolk & Western Railway cut just northwest of Falls Mills, Tazewell County, Virginia, where, as recorded in the Falls Mills Section, page 190, it is red and variegated and 50 feet thick. At this point **Fossil Lot 249 on Map II** was collected by Mr. Price and the writer, the fauna of which is reported as above by Dr. Girty but given in more detail in Chapter XVIII. On the opposite side of Bluestone River, just west of the old mill, it also contains brachiopods, but no collection was made.

In Mercer County this shale is noted in the Stony Gap and Pride Sections and its character and stratigraphic associations are also exhibited in the following local measurement, where it contains much the same fauna as on Bluestone River:

Local Measurement at Fossil Lots 210 and 211.

East River District, Mercer County; in road along Fivemile Creek 4.5 miles southeast of Princeton and 0.9 mile southwest of White School; rocks approximately horizontal; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Princeton Conglomerate (20′)			
1.	**Sandstone, Princeton,** pebbly	20	20
Mauch Chunk Series—Hinton Group (185′)			
2.	Interval, mostly concealed	117	137
3.	**Sandstone, Falls Mills,** shaly	10	147
4.	**Shale, Falls Mills,** black (2170′ B.); contains numerous marine fossils, small pelecypods (chiefly **Myalina**) and ostracods (see **Lot 210**)	3	150
5.	**Limestone, Falls Mills,** shaly	2	152
6.	**Shale, Upper Fivemile** (type locality), green, fissile, with nodules of iron (2148′ B.); contains marine fossils, small pelecypods (see **Lot 211**)	20	172
7.	Concealed	10	182
8.	**Shale, Upper Fivemile** (continued), green, fissile, ferruginous, with marine fossil fragments	13	195
9.	**Coal, Fivemile** (type locality) (0′ 3″) (2125′ B.) **(Exposure No. 765 on Map II)**	..	195
10.	**Shale, Lower Fivemile** (type locality), sandy, with plant fossils	10	205

A more detailed list of the fossils at the above exposure collected by Dr. Girty and the writer and identified by the former will be found in Chapter XVIII.

In Summers County this shale has been recorded in Chapter V in the sections for Bellepoint, Green Sulphur Springs,

Hinton, Pence Springs, Ramp, and Tallery Mountain, its thickness varying from 4 to 60 feet, and its color being usually red or green.

FALLS MILLS LIMESTONE.

The **Falls Mills Limestone** (new) is a yellow, shaly, and lenticular deposit, usually containing marine fossils among which pelecypods and many ostracods have been noted. Its thickness seldom reaches 5 feet and at many localities it is entirely absent. At its type locality, in the cut of the Norfolk & Western Railway along Bluestone River slightly northwest of Falls Mills, Tazewell County, Virginia, it is 5 feet thick and shaly and contains marine fossils, as recorded in the Falls Mills Section, page 190. Here a collection was made by Mr. Price and the writer, there being pelecypods and ostracods as listed in more detail by Dr. Girty in Chapter XVIII.

In Summers County this limestone is recorded in Chapter V in the sections for Bellepoint and Tallery Mountain. At the former locality, as exhibited on page 249, it contains marine fossils, both pelecypods and ostracods, as collected at **Fossil Lot 193 on Map VI** by the writer and as listed in more detail by Dr. Girty in Chapter XVIII.

This limestone appears to be too impure for any economic use, but it is of scientific interest because of its rather abundant fauna.

UPPER FIVEMILE SHALE.

The **Upper Fivemile Shale** (new) is a gray or green and calcareous deposit with occasional streaks of red. It varies from 15 to 25 feet in thickness and often contains marine fossils, both pelecypods and ostracods. Its type locality is in Mercer County on Fivemile Creek along the Princeton-Narrows road 4.5 miles southeast of Princeton and 0.9 mile southwest of White School, and its character and stratigraphic associations at that locality are recorded in the local measurement at **Fossil Lots 210 and 211 on Map II,** published on page 337. Here the shale is green and fissile, with nodules

of iron, and contains pelecypods, collection of which **(Lot 211)** was made by Dr. Girty and the writer and is reported in detail by the former in Chapter XVIII.

In Tazewell County, Virginia, this shale is recorded in the Falls Mills Section of Chapter V, and in Mercer County it is noted in the Stony Gap Section of the same Chapter. In Summers County it is exhibited in the Bellepoint, New Richmond, and Tallery Mountain Sections. At the Beliepoint Section on Wolf Creek Mountain, as published on page 249, the shale contains marine fossils, both pelecypods and ostracods, **Fossil Lot 194 on Map VI** having been collected by the writer. This collection was examined by Dr. Girty and is published in detail in Chapter XVIII.

FIVEMILE COAL.

The **Fivemile Coal** (new) is a lenticular streak which sometimes separates the Upper and Lower Fivemile Shales, but it is often absent and when present seldom reaches one foot in thickness. Its interval below the Princeton Sandstone varies from 175 to 250 feet and that above the Avis Limestone varies from 125 to 240 feet, depending on the locality. Its type locality is along the Princeton-Narrows road on Fivemile Creek 4.5 miles southeast of Princeton and 0.9 mile southwest of White School as indicated by **Coal Exposure No. 765 on Map II**, and as exhibited in the local measurement at **Fossil Lots 210 and 211 on Map II**, page 337. Here it is 0′ 3″ thick at elevation 2125′ B. Elsewhere in Mercer County it was not noted but in Summers County there is a streak of fire clay shale recorded in the Green Sulphur Springs Section of Chapter V, which appears to represent it; and in the Bellepoint Section of the same Chapter there is a five-foot bed of dark shale with a fire clay spring at its horizon. These few exposures merely record an incipient carbonaceous horizon that is of scientific interest but of no economic importance.

LOWER FIVEMILE SHALE.

The **Lower Fivemile Shale** (new) is a green and sandy deposit, varying from 10 to 20 feet in thickness, lying just over

the Tallery Sandstone and just below the Fivemile Coal, and containing marine fossils among which pelecypods of the genus **Myalina,** ostracods, and annelids of the genus **Spirorbis** have been noted. Its type locality is in Mercer County, along the Princeton-Narrows road on Fivemile Creek 4.5 miles southeast of Princeton and 0.9 mile southwest of White School, where it is sandy and contains plant fossils, there being 10 feet of it exposed as exhibited in the local measurement at **Fossil Lots 210 and 211 on Map II,** page 337. In the same county it is recorded in the Stony Gap Section of Chapter V as 10 feet thick and having a red color. In Summers County it is visible in the Bellepoint Section on Wolf Creek Mountain southeast of Bellepoint as published on page 249. Here it is green, sandy, 29 feet thick, and contains marine fossils at the base, **Fossil Lot 195 on Map II** having been collected by the writer, the fauna being as listed above but as described in more detail by Dr. Girty in Chapter XVIII.

TALLERY SANDSTONE.

The **Tallery Sandstone** (new) is a green and shaly but sometimes massive and fairly coarse ledge, varying from 15 to 25 feet in thickness and belonging at an interval of 75 to 100 feet above the base of the Avis Limestone. Its type locality is in Summers County on Tallery Mountain as exhibited in the Tallery Mountain Section, page 268. Here it is shaly, however, and only 10 feet thick at elevation 2117′ B. In Tazewell County, Virginia, it is recorded in the Falls Mills Section of Chapter V as seven feet thick and shaly, and in Mercer County it is noted in the same Chapter in the sections for Athens, Pride, and Stony Gap. On the Princeton-Narrows road along the north side of Fivemile Creek 0.5 mile northwest of White School it is a massive cliff 15 feet thick at elevation 2080′ B.; and on a branch of Payne Branch of Fivemile Creek 1.7 miles west of Hatcher it makes a 15-foot massive cliff at elevation 2400′ B.; and on a more northern branch of Payne Branch 1.3 miles west of Caperton School it is massive and 30 feet thick at elevation 2590′ B.

In Summers County this sandstone is recorded in Chapter V in the sections for Green Sulphur Springs, Hinton, Ramp, Warford, and Tallery Mountain, the latter having been above mentioned as the type locality. In the Wolf Creek Mountain road 0.3 mile northwest of Low Gap School, it is massive and coarse at elevation 2515′ B. West of New River it is visible on the Pipestem-Farley road 1.2 miles southeast of Pipestem, being massive in character and its top having an elevation of 2350′ B.

At the **Concord State Normal School Quarry** in Mercer County along the county road which descends from Athens to Laurel Creek, the lower portion of the Tallery Sandstone has been quarried just east of the town for building stone at elevation 2470′ B., as published in the Athens Section, page 215. Here the stone is greenish-gray, medium-coarse, but streaked with shale, the lower portion being good enough to split into large blocks which have been used for building purposes around Athens.

In localities where this ledge is massive and free from shale it would make very good building stone, since it is usually free from oblique joint-planes and other objectional features, and is often solid enough to be durable, and its texture is not displeasing to the eye.

TALLERY LIMESTONE.

The **Tallery Limestone** (new) is a yellow, shaly, and impure, calcareous bed coming just below the Tallery Sandstone but being frequently absent and when present being only one or two feet thick and at some localities containing marine fossils. Its type locality is in Summers County, on the Tallery Mountain road southeast of True where it is yellow, shaly, and only one foot thick, at elevation 2116′ B., as recorded in the Tallery Mountain Section, page 268. Elsewhere in Summers County it is noted in the sections for Bellepoint, Hinton, and New Richmond, all published in Chapter V, there being marine fossils (pelecypods), in the exposure of the Hinton Section. On the Wolf Creek Mountain road 0.2 mile

northwest of Low Gap School, it is one foot thick and shaly at elevation 2505′ B. In Tazewell County, Virginia, it is recorded in the Falls Mills Section of Chapter V as two feet thick, shaly, and containing marine fossils. No collections were made from this member.

UPPER TALLERY SHALE.

The **Upper Tallery Shale** (new) is usually a greenish-yellow and slightly calcareous deposit belonging just under the Tallery Limestone when the latter member is present, but otherwise immediately below the Tallery Sandstone, and having a thickness of 10 to 15 feet. At some localities it carries marine fossils among which pelecypods of the genus **Myalina** have been noted and there are occasional plant fossils. Its type locality is in Summers County on Tallery Mountain at elevation 2110′ B., as recorded in the Tallery Mountain Section, page 268. Here it contains plant remains, **Fossil Lot 241 on Map VI** having been collected by Dr. David White, Mr. Price, and the writer, as discussed by Dr. White in Chapter XVII.

In Tazewell County, Virginia, this shale is recorded in the Falls Mills Section of Chapter V; and in Mercer County it is noted in the Pride and Stony Gap Sections of the same Chapter, its color at Pride being red. In Summers County, in addition to the type exposure above noted, it is recorded in the sections for Green Sulphur Springs, Hinton, New River, and Ramp, and in the Bellepoint Section, page 250, it is noted as 23 feet thick and as containing numerous marine fossils. Here the writer collected **Fossil Lot 196 on Map VI,** in which **Myalina** is the more abundant genus as listed in detail by Dr. Girty in Chapter XVIII. In the extreme northern end of the county it was observed along the road ascending Meadow Creek 1.1 miles southwest of Meadowbridge at elevation 2190′ B., being dark-green, argillaceous, and containing marine fossils, both pelecypods and gastropods. The whole deposit at that locality is about 50 feet thick but it apparently represents both the Upper and Lower Tallery Shales, the intermediate Tallery Coal being absent.

TALLERY COAL.

The **Tallery Coal** (new) is a lenticular streak having a thickness of one foot or less and belonging between the Upper and Lower Tallery Shales, at an interval above the base of the Avis Limestone which varies from 75 to 185 feet, depending on its locality. Its type locality is at **Coal Exposure No. 766 on Map VI,** on the Tallery Mountain road south of True at elevation 2110′ B., as recorded in the Tallery Mountain Section, page 268. Here the coal is slaty and only 0′ 3″ thick. On Wolf Creek Mountain, as recorded in the Bellepoint Section of Chapter V, its horizon is represented by two feet of sandy shale containing plant fossils, indicating the incipient stage of a coal formation. Elsewhere in the three counties its horizon was not identified but is doubtless present at a few localities although wholly worthless from a commercial standpoint.

LOWER TALLERY SHALE.

The **Lower Tallery Shale** (new) is a red and variegated, or green and sandy, deposit with a thickness of 25 to 35 feet, coming just below the Tallery Coal horizon and just above the Low Gap Sandstone. Its type locality is in Summers County on the Tallery Mountain road south of True as noted in the Tallery Mountain Section, page 268. Here it is sandy and 25 feet thick. In the Bellepoint Section of Chapter V it is noted as 38 feet thick, green, and sandy. In Mercer County it is recorded in the Athens Section of Chapter V as red and variegated and 20 feet thick.

LOW GAP SANDSTONE.

The **Low Gap Sandstone** (new) is a greenish-gray, micaceous, sometimes shaly or sometimes massive ledge, varying in thickness from 20 to 30 feet, and its interval above the base of the Avis Limestone varying from 80 to 160 feet. Its type locality, as exhibited in the Bertha Section, page 260, is in Summers County on Wolf Creek Mountain in the public road slightly east of and above the Low Gap School at elevation

2480′ B., its character at that locality being shaly. In the same county it is recorded in the Green Sulphur Springs Section of Chapter V where it is five feet thick and of a reddish-brown color and in the road on the south side of Fisher Mountain 2.1 miles east of Green Sulphur Springs, it is visible at elevation 2360′ B., being 25 feet thick and shaly.

In Tazewell County, Virginia, it is recorded in the Falls Mills Section of Chapter V as 10 feet thick and shaly; and in Mercer County it is noted in the Pride Section as 25 feet thick and shaly, and in the Stony Gap Section as only five feet thick and shaly.

So far as known this sandstone has not been quarried in the three counties and its generally shaly character would appear, as a rule, to preclude its use as a building stone.

LOW GAP LIMESTONE.

The **Low Gap Limestone** (new) is a yellow and impure calcareous stratum, being usually shaly or sandy, and carrying marine fossils, its position being only a few feet below the Low Gap Sandstone, and its thickness from one to five feet. Its type locality is in Summers County on Wolf Creek Mountain along the hill road above and slightly southeast of Low Gap School at elevation 2475′ B., as recorded in the Bertha Section, page 260. Here it is two feet thick, yellow, and shaly and carries marine fossil fragments, being separated from the Low Gap Sandstone by three feet of green shale. In the same county it is also noted in the section for Bellepoint as two feet thick, yellow, and shaly, and in that for Hinton as one foot thick and sandy. Near its type locality it is again exposed on the Wolf Creek Mountain road 0.2 mile north of Low Gap School at elevation 2460′ B., being yellow, shaly, and five feet thick. In the northern end of the county it is exposed in a road along the south side of Fisher Mountain 2.1 miles east of Green Sulphur Springs at elevation 2345′ B., being hard, sandy, and two feet thick. West of New River it was noted on a mountain road descending to a branch of Madam Creek 1.5 miles east of Jumping Branch village, at

elevation 2205′ B., being yellow and five feet thick. In Mercer County it was not observed.

This limestone is too impure to be of any economic use but it is of scientific interest because of the presence of marine fossils. No collection of these was obtained, however, at any point.

LOW GAP SHALE.

The **Low Gap Shale** (new) is a red and variegated deposit filling the interval between the Low Gap Limestone and Avis Sandstone, its thickness varying from 5 to 40 feet. Its type locality, as indicated in the Bertha Section, page 260, is in Summers County on Wolf Creek Mountain along the hill road above and slightly southeast of Low Gap School at elevation 2465′ B., being there red and variegated and 10 feet thick. In the same county it is recorded in the sections for Bellepoint and Green Sulphur Springs, both published in Chapter V. In Mercer County it is noted in the Stony Gap and Athens Sections of Chapter V, there being marine fossils (pelecypods) at the latter locality, where the shale has become quite calcareous. No collection of fossils was made from this member at any locality.

AVIS SANDSTONE.

The **Avis Sandstone** (new) is a greenish-gray, micaceous, massive or shaly, and quite persistent ledge, having a thickness that varies from 10 to 35 feet, and belonging at an interval of 50 to 100 feet above the base of the Avis Limestone. From this limestone it is separated only by the green and calcareous Upper Avis Shale, making its recognition quite easy as a rule. It is named from association with the Avis Limestone, its type locality being high up against the sides of the mountains in the vicinity of Hinton and Avis, Summers County. In the Hinton Section, page 247, it is recorded as 15 feet thick and shaly; and in that for Bellepoint, page 250, it is 25 feet thick and shaly. Elsewhere in this county it appears in the sections for Alderson, Bertha, Green Sulphur

Springs, Ramp, Tallery Mountain, and Warford, all published in Chapter V, its character at these points being usually flaggy and shaly, and its color prevailingly green. In Mercer County it is recorded in the Athens Section of Chapter V as 20 feet thick, making a green, fine-grained cliff; and in that for Stony Gap it is 5 feet thick and massive, being exposed along the Bluefield-Princeton road only a few hundred feet north of Stony Gap village.

So far as known this sandstone has not been quarried and its generally shaly or flaggy character would appear to preclude its use as a building stone, although there may be a few exposures where it becomes durable enough to be of some local value.

UPPER AVIS SHALE.

The **Upper Avis Shale** (new) is a green or yellow, calcareous and usually fissile deposit, varying from 20 to 25 feet in thickness, and generally carrying abundant marine fossils of which the pelecypod **Myalina** appears to be the most common genus. It occupies the interval between the Avis Sandstone and Avis Limestone, its type locality being in the region around Avis, Hinton, and Bellepoint, Summers County. In the Hinton Section, page 247, its upper 25-foot portion is green and its lower 15-foot portion is yellow and calcareous with marine fossil fragments. In the Bellepoint Section, page 250, it is green and calcareous, 40 feet thick, and carries numerous marine fossils, mostly pelecypods, among which **Myalina** is especially abundant. **Fossil Lot 197 on Map VI** was collected at this point by the writer and has been designated as the type collection, a more detailed report on the fauna of which by Dr. Girty will be found in Chapter XVIII. A little farther south it is again well exposed on the Tallery Mountain road, where, as exhibited in the Tallery Mountain Section, page 268, it is 35 feet thick and mostly green, there being a limestone one foot thick coming 10 feet below the top and having marine fossils (pelecypods). The portion below the limestone, consisting of 24 feet of green shale, also contains

marine fossils among which pelecypods were noted. From this portion Dr. Girty and the writer collected **Fossil Lot 203 on Map VI,** the detailed report of which by Dr. Girty will be found in Chapter XVIII. Elsewhere in Summers County it is recorded in the Alderson, Bertha, Green Sulphur Springs, Ramp, and Warford Sections, all published in Chapter V.

In Mercer County it is exhibited in the Athens Section of Chapter V, being yellowish-green, partly calcareous and partly sandy, 10 feet thick and containing marine fossils (pelecypods); and in the Stony Gap Section it is yellow and 15 feet thick.

AVIS LIMESTONE.

The **Avis Limestone** (new), formerly termed the **Hinton Limestone** by Krebs,[12] is one of the most persistent and easily recognized members of the Hinton Group. Its original designation by Krebs as the "Hinton Limestone" from its exposures around the city of Hinton, Summers County, has been further employed by the writer in the Webster, Nicholas, Tucker, and Mineral-Grant Reports of the Survey where it was doubtfully applied to a calcareous horizon in the lower part of the Mauch Chunk Series, the final correlation of which is still in doubt. It is evident, however, that the use of the term "Hinton" as a name for this or any other member is in conflict with the prior use of the title as a group name of one of the major subdivisions of the series by Campbell in 1896, especially since this group title has become firmly fixed in the literature of these sediments. That being the case it is considered expedient and proper to rename this limestone from the adjoining town of Avis where the type locality will be the same and only the confusing name will be avoided.

The Avis Limestone in the vicinity of Avis and Hinton as well as at most other points in Summers and Mercer Counties, is steel-gray in color and mostly hard and fairly pure except that there is almost invariably a shaly and impure

[12] C. E. Krebs, Raleigh County and Western Portions of Mercer and Summers Counties Report, W. Va. Geol. Survey, pp. 75, 76, and 88; 1916.

streak near the middle, dividing the ledge into two very distinct benches. Its thickness varies from 20 to 40 feet, the larger figures being applicable to Summers and the northern part of Mercer County and the smaller to the southwestern corner of the latter county, where the bed thins away perceptibly. Both the hard benches and the shaly middle portion contain abundant marine fossils among which brachiopods, pelecypods, gastropods, crinoids, and fenestelloid bryozoa have been noted, the latter being more common in the shaly zone, and being of especial significance because of their almost total absence in other members of the Bluestone, Princeton, and Hinton Groups as well as in the upper part of the Bluefield.

On the road which ascends Keeney Mountain east of Hinton this limestone is well exposed at elevation 2065′ B., as recorded in the Hinton Section, page 247, being steel-gray and 40 feet thick, with numerous marine fossils. On the road which climbs Wolf Creek Mountain from Bellepoint it outcrops at elevation 2085′ B., as exhibited in the Bellepoint Section, page 250. Here is is partly gray and hard and partly yellow and shaly, being 45 feet thick and containing abundant marine fossils among which brachiopods, pelecypods, gastropods, and bryozoa were noted. **Fossil Lot No. 198 on Map VI** was collected at this locality by the writer and has been designated as the type collection, of which the detailed list of fauna by Dr. Girty will be found in Chapter XVIII.

Elsewhere in Summers County this limestone is recorded in the sections for Alderson, Bertha, Green Sulphur Springs, Pence Springs, Ramp, Tallery Mountain, and Warford, all published in Chapter V, the thickness and characteristics being much the same as above described.

In Mercer County it is noted in the section for Athens where it has much the same character as at Hinton and Avis there being abundant marine fossils. It is also exhibited in the Stony Gap Section of Chapter V, being exposed along the Bluefield-Princeton road a few hundred feet north of Stony Gap village, but here it is only 10 feet thick and very shaly.

On Bluestone River northwest of Graham it was doubtfully identified at the following exposure:

Local Measurement at Fossil Lot 125.

Tazewell County, Virginia; in N. & W. Ry. cut on east side of Bluestone River 0.8 mile northwest of Graham; dip, northwest 24°; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (35′)		
1. **Limestone, Avis (?),** shaly (2360′ B.); with marine fossils, pelecypods (especially **Myalina**) (see **Lot 125**)	10	10
2. Shale, red and variegated	25	35

At the above point **Fossil Lot 125 on Map II** was collected by the writer and the detailed list of fauna as identified by Dr. Girty will be found in Chapter XVIII. On the Bluefield-Bramwell road 0.8 mile north of Brush Creek village it is visible at elevation 2525′ B., being steel-gray in color, 25 feet thick, and having a southward dip of 15°. On the same road it is visible on a branch of Bluestone River 1.1 miles northeast of Graham at elevation 2470′ B., having a thickness of 15 to 20 feet and a northward dip of 15°, and being quite shaly. On Blacklick Creek 1.4 miles northwest of Princeton it is exposed at elevation 2435′ B., being gray and shaly and having a southward dip of 20°, and a visible thickness of 10 feet, part of the ledge being apparently concealed. On Twelvemile Creek 0.5 mile northwest of Ingleside it stands on edge in the gap of the creek, being 5 feet thick, shaly, and having marine fossils. On Fivemile Creek it is visible in the Princeton-Narrows road 0.3 mile northward from White School, the exposure consisting of 5 feet of shaly and impure limestone at elevation 2040′ B.; and there being abundant marine fossils among which brachiopods, pelecypods, crinoids, and bryozoa were noted by Mr. Price and the writer. On Payne Branch of Fivemile Creek it is exposed in the public road 0.9 mile north of Hatcher, being 10 feet thick and shaly at elevation 2185′ B.; and farther northward, on the road which passes from Payne Branch toward Athens, it is visible at elevation 2380′ B.; having a thickness of 20 feet and containing numer-

ous marine fossils among which bryozoa, brachiopods, and other types were noted, the character of the stone being shaly. On Hales Branch of Fivemile Creek 1.2 miles northeast of Goodwyn Chapel it is exposed at the foot of the mountain road toward Elgood at elevation 2060′ B., being 15 feet thick and shaly, and containing marine fossils, among which brachiopods, crinoids, and other forms were noted by Mr. Price and the writer. Farther northwest it is visible on the ridge road between Hackett and Island Creeks 0.9 mile northeast of Pettry, where it is steel-gray with shaly streaks and with a thickness of 35 feet, its elevation being 2410′ B., and its dip toward the north. Farther west there are various exposures along Tracy Fork of Laurel Creek and on Laurel Creek itself southeast of Athens, and it has been quarried at some of these exposures as will be described in more detail in Chapter XIV under the subject of "Limestone."

In Monroe County the Avis Limestone is above the topography except along the axis of the Hurricane Ridge Syncline in part of the region between Peterstown and Rock Camp Creek, but if present along this limited outcrop it has changed much in character and has become almost unrecognizable. The following locality, however, is doubtfully assigned to this member:

Local Measurement at Fossil Lot 160.

Red Sulphur District, Monroe County; on Mud Run of Rich Creek at junction of short private road with public highway 1.1 miles northeast of Brick Church; dip, southeast 10°; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (46′)			
1.	Shale, sandy	..	..
2.	Shale, calcareous, with marine fossils..... 5′		
3.	Limestone, shaly, with marine fossils..... 1 — **Avis (?) Limestone**	6	6
	Collection from Nos. 2 and 3 of section, brachiopods, and numerous ostracods (see **Lot 160**).		
4.	Shale, green	40	46
5.	Shale, red	..	..

At the above locality **Fossil Lot 160 on Map IV** was collected by the writer and the identification of the fauna by

Dr. Girty will be found in Chapter XVIII. There is much doubt as to this identification since both the physical character of the formation and the fossils are much at variance with the usual character of the Avis, and just south of the exposure the strata are suddenly overturned, while in the ridge to the north there is little visible except red shale, so that its identification by stratigraphic association is hardly possible.

The base of the Avis Limestone has been used as the key rock of the structure contours on Maps II, IV, and VI, and in Summers County its outcrop may also be noted on Figure 14 showing outcrops of pure limestone as published in Chapter VIII. Plate IX is a good illustration of its upper heavy ledge.

Beyond the limits of the three counties under study this limestone may be noted at several points in southwest Virginia, and also at a few points in Tennessee, and toward the northeast it persists up the Greenbrier Valley and apparently northward into southern Pennsylvania.

LOWER AVIS SHALE.

The **Lower Avis Shale** (new) is a yellow and calcareous deposit occurring just under the Avis Limestone, having a thickness of 20 to 30 feet with abundant marine fossils among which pelecypods, brachiopods, and ostracods have been noted. Its type locality is in Summers County in the region around Avis, Hinton, and Bellepoint. In the Hinton Section, page 247, it is 15 feet thick, yellow and calcareous, at elevation 2050′ B. In the Bellepoint Section, page 250, it is yellow, calcareous, and 15 feet thick at elevation 2050′ B. Here the writer collected **Fossil Lot 199 on Map VI,** the fauna consisting largely of pelecypods, with a few brachiopods and ostracods, as identified by Dr. Girty in Chapter XVIII. This locality has been designated as the type collection. In the same county the shale is recorded in the sections for Alderson, Bertha, Green Sulphur Springs, Pence Springs, Ramp, and Warford, all published in Chapter V. On Tallery Mountain south of True its horizon appears to be occupied by red shale

as indicated in No. 28 of the Tallery Mountain Section, page 268. Here the writer collected **Sample No. 631R** for chemical analysis on the land of **Wylie McGraw,** the composition of which is reported as follows by Mr. B. B. Kaplan, Chemist of the Survey:

	Per cent.
Silica (SiO_2)	57.50
Ferric Iron (Fe_2O_3)	7.90
Alumina (Al_2O_3)	22.26
Lime (CaO)	1.10
Magnesia (MgO)	2.70
Loss on ignition	7.40
Total	98.86

From the above analysis it would appear that the exposure sampled would make red building brick, but in regions where the shale is calcareous it could not be so utilized.

In Mercer County the horizon of the Lower Avis Shale appears to be occupied at some localities by red shale as exhibited by No. 44 of the Stony Gap Section, page 197. In Monroe County, its horizon occurs only along a part of the Hurricane Ridge Syncline where no identification of it was made.

PAYNE BRANCH SANDSTONE.

The **Payne Branch Sandstone** (new) is usually greenish-gray or reddish-brown and shaly, with a thickness of 20 to 35 feet, its position being just below the Lower Avis Shale, and the interval of its base below the base of the Avis Limestone being 40 to 65 feet. Its type locality is in Mercer County on the north side of Payne Branch of Fivemile Creek 0.8 mile southwest of Caperton School and 2.2 miles north of Hatcher. Here it makes a shaly cliff 20 to 30 feet thick at elevation 2305′ B. Farther south it is visible on the west side of Payne Branch one mile north of Hatcher, making a reddish-brown cliff 30 feet thick at elevation 2215′ B.; and on a branch of the same stream 1.1 miles west of Hatcher it is 10 feet thick and shaly at elevation 2185′ B. On Hales Branch of Fivemile Creek at the foot of the mountain road to Elgood 1.1 miles northeast of Goodwyn Chapel, it makes a cliff at elevation

PLATE XIX.—Contact of Alderson Limestone of Greenbrier Series (left) with Lillydale Shale of Bluefield Group of Mauch Chunk (right), on Bluefield-Princeton road 0.5 mile southwest of Stony Gap, Mercer County, looking west. Beds slightly overturned. Present angle of dip, 65°. See Stony Gap Section. (Photo. by Palmer & Fowler).

2005' B., its character being flaggy and the interval of its base below the Avis Limestone being 55 feet.

In Summers County this sandstone is recorded in the Bellepoint, Bertha, Tallery Mountain, and Warford Sections of Chapter V, its character being usually reddish-brown and shaly, and its thickness varying from 5 to 10 feet. In Monroe County it was not identified.

So far as known this ledge has not been quarried and its shaly nature would appear to preclude it from use as a building stone except for limited local purposes.

PAYNE BRANCH SHALE.

The **Payne Branch Shale** (new) coming just under the Payne Branch Sandstone is a red and variegated deposit usually 15 to 20 feet thick, but sometimes increasing to a larger figure. It is named from its association with the Payne Branch Sandstone, its type locality being in Mercer County along Payne Branch of Fivemile Creek where it outcrops below the sandstone at localities above noted. In northeastern Mercer County it may generally be observed in the region of its outcrop. In Summers County it is recorded in the sections for Bellepoint, Bertha, Green Sulphur Springs, Tallery Mountain, and Warford, all published in Chapter V, its color being usually red and its thickness varying from 15 to 90 feet.

This shale is usually quite free from lenticular sandstone and would apparently be good material for the manufacture of building brick or tile. On account of its content of iron oxide it would burn to a red color.

HACKETT SANDSTONE.

The **Hackett Sandstone** (new) is usually greenish-gray being sometimes massive, but often made up of thick, hard flags separated by streaks of shale, its whole thickness varying from 30 to 45 feet, and its position being just below the Payne Branch Shale with an interval of 80 to 130 feet below the base of the Avis Limestone. Its type locality is in Mercer County on the ridge road between Hackett and Island Creeks, 1.6

miles northeast of Pettry. Here it makes a plateau along the ridge, being massive and 30 feet thick with the elevation of its top 2340′ B. Farther south it is visible at a road fork on a branch of Payne Branch of Fivemile Creek one-half mile west of Hatcher at elevation 2145′ B., its character being hard. On Payne Branch at the point where the Hurricane Ridge Syncline crosses the branch it is again exposed, its hard flags being quite conspicuous. In the Stony Gap Section of Chapter V it is recorded as 15 feet thick, gray, and coarse.

In Monroe County it was not identified but in Summers County it is exhibited in the sections for Bellepoint, Bertha, Green Sulphur Springs, Hinton, New Richmond, Pence Springs, Ramp, Tallery Mountain, and Warford, all published in Chapter V, being sometimes reddish-brown and shaly and varying in thickness from 10 to 75 feet.

So far as known this sandstone has not been quarried but at localities where it is composed of hard flags these might be used for masonry with satisfaction.

HACKETT SHALE.

The **Hackett Shale** (new) coming just under the Hackett Sandstone is a thick deposit composed mainly of red shale with occasional streaks of sandstone or limestone and with occasional marine fossils in the lower part, its thickness being 100 to 200 feet. It is named from association with the Hackett Sandstone, its type locality being in eastern Mercer County in the region above detailed for the Hackett Sandstone. In the same county it is recorded in the Stony Gap Section of Chapter V, as red, variegated, and 243 feet thick. In Monroe County it was not identified with certainty although its horizon outcrops along a portion of the Hurricane Ridge Syncline. In Summers County it is recorded in the sections for Bellepoint, Bertha, Green Sulphur Springs, Hinton, New Richmond, Pence Springs, Ramp, Tallery Mountain, and Warford, all published in Chapter V, its range in thickness being from 30 to 290 feet. In this county as well as in Mercer it appears to be the thickest and most conspicuous red bed in the Hinton or any other group of the Mauch Chunk Series.

On the road ascending Keeney Mountain 0.5 mile east of Hinton, the writer collected **Sample No. 633R** for chemical analysis (see No. 41 of Hinton Section, page 247) from the upper 100 feet of this shale on the land of the **Hinton Water, Light & Supply Company,** its composition being reported as follows by Mr. Kaplan:

	Per cent.
Silica (SiO_2)	57.36
Ferric Iron (Fe_2O_3)	7.61
Alumina (Al_2O_3)	22.18
Manganous Oxide (MnO)	trace
Lime (CaO)	1.51
Magnesia (MgO)	2.70
Loss on ignition	7.20
Total	98.56

This shale would appear to be suitable for making building brick or tile and would burn to a deep red color owing to its content of iron, and it could easily be quarried around Hinton since it is well exposed on the mountain east of the city where it has been furrowed into many tiny, transverse ridges by descending rivulets of water.

In Mercer County the following exposure of the lower portion of the Hackett Shale is visible at the mouth of Payne Branch:

Local Measurement at Fossil Lot 212.

East River District, Mercer County; on north side of Fivemile Creek just west of the mouth of Payne Branch and 1.3 miles northwest of Oakvale; dip, 0°; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (35′)		
1. **Shale, Hackett,** sandy	10	10
2. Sandstone	3	13
3. **Shale, Hackett** (continued), sandy, dark, fissile (1895′ B.); contains numerous marine fossils (see **Lot 212**)	10	23
4. **Limestone, Tophet,** black, hard	2	25
5. **Shale, Upper Tophet,** sandy, to creek	10	35

At the above exposure Dr. Girty and the writer collected **Fossil Lot 212 on Map II,** the detailed report of the fauna as identified by the former being published in Chapter XVIII.

TOPHET LIMESTONE.

The **Tophet Limestone** (new) is a shaly, calcareous bed, coming just below the Hackett Shale, and usually varying in thickness from 3 to 5 feet but sometimes being entirely absent. As a general rule it carries marine fossils. Its type locality is in the southern end of Summers County on the hill road toward Lick Creek 0.2 mile north of Tophet where it outcrops at elevation 1900′ B., being shaly, 5 feet thick, and having marine fossils, and its interval above the base of the Tophet Sandstone being 80 feet. A little farther north it is again visible on a branch of Lick Creek 1.1 miles northeast of Lick Creek Post-office, being yellow, shaly, and 5 feet thick at elevation 1815′ B. In Summers County, also, it is recorded in the sections for Bellepoint, Hinton, Green Sulphur Springs, Pence Springs, and Tallery Mountain. In eastern Mercer County it is visible just above drainage at the mouth of Payne Branch of Fivemile Creek at elevation 1893′ B., being 2 feet thick, hard, and black, as exhibited in the Local Measurement at **Fossil Lot 212 on Map II**, page 355. Slightly farther east it is exposed in the Princeton-Narrows road along the north side of Fivemile Creek at elevation 1870′ B., being 3 feet thick, shaly, and bedded in shale. No collection of marine fossils were made in this member.

UPPER TOPHET SHALE.

The **Upper Tophet Shale** (new) is a red deposit usually only 10 to 15 feet in thickness but occasionally increasing much beyond these figures, its position being between the Tophet Limestone and Tophet Sandstone, and its type locality being in the southern end of Summers County in the vicinity of Tophet where it fills an interval of 65 feet although not fully exposed. Elsewhere in Summers County it is recorded in the sections for Bellepoint, Bertha, Green Sulphur Springs, Hinton, New Richmond, and Tallery Mountain, all published in Chapter V. In Mercer County it is exhibited in the Stony Gap Section of the same Chapter, being red and variegated and partly sandy. This shale is much like the Hackett and

when the intervening Tophet Limestone is absent the two beds do not appear to be capable of separate identification.

TOPHET SANDSTONE.

The **Tophet Sandstone** (new) is a reddish- or greenish-brown, shaly ledge, varying from 15 to 25 feet in thickness and having an interval below the base of the Avis Limestone that ranges from 160 to 375 feet, depending on the southward thickening of the measures. Its type locality is in the southern end of Summers County on the hill road toward Lick Creek 0.3 mile northeast of Tophet, where it is 15 feet thick, reddish-brown, and shaly at elevation 1820′ B. Elsewhere in Summers County it is recorded in the sections for Bertha, Green Sulphur Springs, Hinton, New Richmond, Ramp, and Tallery Mountain, all published in Chapter V. In the northern end of the county it is also visible at a road fork on the head of Duncan Branch of Lick Creek two miles eastward from Green Sulphur Springs at elevation 2070′ B., being reddish-brown, shaly, and 15 feet thick. In Mercer County it is exhibited in the Stony Gap Section of Chapter V, being 10 feet thick and greenish-brown.

So far as known the Tophet Sandstone has not been quarried and its shaly nature does not favor its use for general building purposes.

TOPHET COAL.

The **Tophet Coal** (new) is a thin and lenticular streak, coming just below the Tophet Sandstone, from the association with which it receives its name, and at the same approximate intervals below the Avis Limestone as above enumerated for the sandstone. It is visible at **Coal Exposure No. 767 on Map VI** in Summers County on the Tallery Mountain road south of True, at elevation 1695′ B., coming just under 25 feet of shaly sandstone. Here it is only a streak and apparently it never become of much significance in any of the three counties.

LOWER TOPHET SHALE.

The **Lower Tophet Shale** (new) is an argillaceous horizon coming just below the Tophet Coal and just above the Goodwyn Sandstone, being usually red and variegated, with occasional streaks of sandstone, and having a thickness of 20 to 35 feet. It is named from association with other members of the Tophet stage, its type locality being in the southern end of Summers County in the vicinity of Tophet. Elsewhere in this county it is recorded in the sections for Bertha, Green Sulphur Springs, Hinton, New Richmond, and Tallery Mountain, all published in Chapter V. At the latter locality, as exhibited on page 269, it is mostly red with streaks of red shaly sandstone, but toward the top and next to the Tophet Coal it becomes a yellow fire clay shale and contains plant fossils. Here **Fossil Lot 242 on Map VI** was collected by Dr. David White, Mr. Price, and the writer, the discussion of which by Dr. David White will be found in Chapter XVII.

In Mercer County this shale outcrops over a considerable area and appears to be present but no good exposures were noted. In Monroe County it should outcrop along part of the Hurricane Ridge Syncline between Peterstown and Rock Camp Creek.

GOODWYN SANDSTONE.

The **Goodwyn Sandstone** (new) is a greenish-gray and massive, or reddish-brown and shaly ledge, coming just below the Lower Tophet Shale and at an interval below the base of the Avis Limestone varying from 215 to 450 feet, and having a thickness of 25 to 40 feet. Its type locality is in eastern Mercer County along the Princeton-Narrows road on Fivemile Creek at Goodwyn Chapel where its associations are exposed in the following local measurement:

Local Measurement at Fossil Lot 213.

East River District, Mercer County; on north side of Fivemile Creek opposite Goodwyn Chapel and 0.9 mile northwest of Oakvale; dip, northwestward 9°; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (48′)		
1. **Sandstone, Goodwyn** (type locality), greenish-gray, massive, cliff rock, with 5 feet of shaly breccia at base (see plate X)	40	40
2. **Shale, Upper Goodwyn** (type locality), dark, fissile (1830′ B.); contains marine fossils, pelecypods (largely **Myalina**), and numerous ostracods (see **Lot 213**)	1½	41½
3. Shale, dark, bituminous, with plant fossils, **Goodwyn Coal horizon** (type locality)	1½	43
4. **Shale, Lower Goodwyn** (type locality), dark, calcareous, with marine fossils, to creek	5	48

At other points in eastern Mercer County and southern Summers County this ledge may be identified, and in the latter county it is recorded in the sections for Alderson, Bellepoint, Bertha, Green Sulphur Springs, Hinton, New Richmond, Ramp, and Tallery Mountain, all published in Chapter V, its thickness varying from 5 to 35 feet, and its character being reddish-brown and shaly. In Monroe County it was not identified but should be present along a portion of the Hurricane Ridge Syncline.

So far as known this sandstone has not been quarried and it is generally too shaly to be used successfully for building purposes, although there may be occasional exposures where it could be used for local construction.

UPPER GOODWYN SHALE.

The **Upper Goodwyn Shale** (new) is a dark, sandy, and fissile deposit varying from five to ten feet in thickness and coming just below the Goodwyn Sandstone, its type locality being in eastern Mercer County on Fivemile Creek at Goodwyn Chapel where it is visible under the sandstone cliff. At this point it is only one and one-half feet thick but contains marine fossils, among which pelecypods of the genus **Myalina** and numerous ostracods were noted. Here Dr. Girty and the writer collected **Fossil Lot No. 213 on Map II** as detailed in the local measurement above. Dr. Girty's report on this fauna will be found in Chapter XVIII.

In Summers County this shale is recorded in the sections for Green Sulphur Springs and Tallery Mountain, both published in Chapter V, but at these localities it is only a red bed.

GOODWYN COAL.

The **Goodwyn Coal** (new) is a dark bituminous bed, containing plant fossils and other signs of an incipient coal horizon, but so far as known never reaching the actual stage of coal formation. Its type locality is in eastern Mercer County at Goodwyn Chapel on Fivemile Creek where it is one and one-half feet thick, its base being only three feet below the ledge of the Goodwyn Sandstone, from the association with which it derives its title. It is named as a matter of record for whatever studies may be made in the future of its organic remains.

LOWER GOODWYN SHALE.

The **Lower Goodwyn Shale** (new) is a bed that is dark and calcareous, with marine fossils near the top, and red and variegated with streaks of sandstone near the base, its whole thickness being from 40 to 75 feet, and its position being just below the Goodwyn Coal horizon and only 5 to 15 feet below the Goodwyn Sandstone. Its type locality is in eastern Mercer County at Goodwyn Chapel on Fivemile Creek where only its upper 5 feet are exposed, as recorded in the local measurement at **Fossil Lot No. 213 on Map II,** page 359. In Summers County this shale is recorded in the sections for Alderson, Bellepoint, Bertha, Green Sulphur Springs, Hinton, New Richmond, Ramp, and Tallery Mountain. No collection of its marine fossils was made at any locality.

UPPER BELLEPOINT SANDSTONE.

The **Upper Bellepoint Sandstone** (new) is a reddish-brown or greenish-gray, medium-coarse, and sometimes massive but often shaly ledge, the interval of its base below the base of the Avis Limestone varying from 335 to 600 feet, depending on the southward expansion of the series, and its thickness being 30 to 40 feet. Its type locality is in Summers County in the bluffs above New and Greenbrier Rivers near Bellepoint, as exhibited in the following local measurement:

Local Measurement at Fossil Lot 183.

Greenbrier District, Summers County; on north side of Greenbrier River 0.2 mile north of Bellepoint; gentle northwest dip; measured with aneroid and arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (210′)			
1.	**Sandstone, Upper Bellepoint** (type locality), dark-brown, massive at top, somewhat shaly at base, makes cliffs (1560′ B.)	30	30
2.	Shale, variegated..... 5′ ⎫ **Upper Bellepoint**		
3.	Concealed .....25 ⎭ (type locality)....	30	60
4.	**Sandstone, Middle Bellepoint,** shaly.....	10	70
5.	**Shale, Middle Bellepoint** (type locality) (1518′ B.); contains marine fossils, pelecypods (see **Lot 183**)	2	72
6.	**Sandstone, Lower Bellepoint,** shaly and concealed.	88	160
7.	**Sandstone, Stony Gap (Hinton** of Stevenson), mostly massive (1380′ B.).....	50	210
Mauch Chunk Series—Bluefield Group (20′)			
8.	Concealed, and sandstone containing shale breccia to Greenbrier River at Bellepoint bridge (1360′ B.)	20	230

The Upper Bellepoint Sandstone is one of the most persistent ledges in the entire Hinton Group and its reddish-brown color does not often disappear although there are occasional exposures where the prevailing tone is green. In Summers County it makes frequent cliffs in the mountains on either side of New and Greenbrier Rivers and several of their major tributaries. In Chapter V it is recorded in the sections for Alderson, Bellepoint, Bertha, Green Sulphur Springs, Hinton, Indian Mills, New Richmond, Pence Springs, Ramp, Tallery Mountain, and Warford. At the Tallery Mountain locality just south of True it becomes a great ledge 95 feet thick but apparently has combined with the Middle Bellepoint Sandstone, the intervening shale having disappeared. In the northern end of the county it makes a shaly cliff at elevation 1510′ B. on Lick Creek 1.2 miles northeast of New Richmond, and on Duncan Branch of Lick Creek 1.7 miles southeast of Green Sulphur Springs it makes a shaly, reddish-brown cliff 25 feet thick at elevation 1900′ B. On Laurel Creek from Ramp westward to Mud Lick Run there are several exposures not far above drainage, the ledge being prominent enough to make shaly cliffs. Along the east side of New River north

of Hinton it is visible 1.2 miles northwest of Brooks at elevation 1550′ B., making a 50-foot cliff, and one-fourth mile north of Tug Creek it makes a 40-foot cliff at elevation 1505′ B. In the region south of Hinton it is visible on the south side of Greenbrier River one-fourth mile east of Bellepoint at elevation 1600′ B., making a massive 10-foot cliff. Farther south it makes numerous exposures along an upland road which passes from Wheel Run School northeastward along the head of Johnnycake Fork. On the west side of Bluestone River northeast of Lilly it makes cliffs at several exposures, and in the extreme southern end of the county it makes a shaly cliff on the hill road to Lick Creek 0.4 mile northeast of Tophet, the elevation of the top being 1735′ B.

In Mercer County the Upper Bellepoint Sandstone becomes more shaly but in the bed of Fivemile Creek 0.3 mile southeast of Goodwyn Chapel in the eastern end of the county it is exposed as a massive, reddish-brown ledge at elevation 1775′ B., there being a rapid northward dip in the vicinity of Stony Gap. Farther southwest its horizon appears to be largely occupied by shale although it is only partly exposed.

In Monroe County this sandstone was not identified but it should occur at various points along the Hurricane Ridge Syncline between Peterstown and Rock Camp Creek.

So far as known the Upper Bellepoint Sandstone has never been quarried but it is often hard enough to be quite durable, and since it has a pleasing texture and convenient exposures its use as a stone for building purposes where extreme strength and hardness are not required would be worth serious consideration.

UPPER BELLEPOINT SHALE.

The **Upper Bellepoint Shale** (new) is a red and variegated and argillaceous, or green and sandy deposit, having occasional streaks of impure limestone, and carrying marine fossils among which are pelecypods and many ostracods. Its thickness varies from 30 to 35 feet, as a rule, and its position is just under the Upper Bellepoint Sandstone, the type locality being in Summers County on the lower slope of Keeney Mountain

0.2 mile north of Bellepoint, as exhibited in the Local Measurement at **Fossil Lot No. 183 on Map II,** page 361. Here it contains 5 feet of red and variegated shale at the top but the lower 25 feet are concealed so that its further characteristics may be better studied elsewhere. On the south side of Greenbrier River on the mountain road just southeast of Bellepoint it is fully exposed, as recorded in the Bellepoint Section, page 250, being 35 feet thick, red, and variegated. Elsewhere in the same county it is recorded in the sections of Chapter V for Alderson, Bertha, Green Sulphur Springs, Hinton, and New Richmond; and there are many other good exposures along New River and its major tributaries where it may be studied at pleasure, the following being one of the most interesting:

Local Measurement at Fossil Lot 201.

Green Sulphur District, Summers County; in railroad cut on north side of Meadow Creek 0.3 mile east of its mouth and 0.3 mile north of Meadow Creek Station; gentle northwest dip; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (70′)		
1. Sandstone, massive, cliff.10′ } **Upper**		
2. Concealed .....10 } **Bellepoint**	30	30
3. Sandstone, cliff.....10 } **Sandstone.**		
4. Concealed and **shale, Upper Bellepoint,** red and variegated	20	50
5. Limestone, part of **Upper Bellepoint Shale,** yellowish-green, shaly (1293′ B.); contains pelecypods and numerous ostracods (see **Lot 201**)....	7	57
6. **Shale, Upper Bellepoint** (continued), red and variegated, to Meadow Creek.....	13	70

At the above locality **Fossil Lot 201 on Map VI** was collected by the writer, the more detailed report of its fauna by Dr. Girty being found in Chapter XVIII.

In Mercer County the Upper Bellepoint Shale outcrops over a considerable area but its identification is more uncertain than in the Hinton region, since the Middle Bellepoint Sandstone has partly disappeared, allowing the Upper and Middle Bellepoint Shales to join together. The same condition is more or less apparent along a portion of the Hurricane Ridge Syncline in Monroe County where these strata outcrop.

MIDDLE BELLEPOINT SANDSTONE.

The **Middle Bellepoint Sandstone** (new), belonging 40 to 50 feet, base to base, below the Upper Bellepoint Sandstone, is a greenish-gray or reddish-brown sandstone, usually shaly and varying from 5 to 25 feet in thickness. Its type locality is in Summers County on the lower slope of Keeney Mountain 0.2 mile north of Bellepoint, where, as exhibited in Local Measurement at **Fossil Lot 183 on Map VI,** page 361, it is shaly and 10 feet thick at elevation 1520′ B. Elsewhere in Summers County it is recorded in the sections of Chapter V for Alderson, Bellepoint, Bertha, Green Sulphur Springs, Hinton, and New Richmond, and in the Tallery Mountain Section it has coalesced with the Upper Bellepoint Sandstone to form a huge cliff 95 feet thick. On the east side of New River at a branch 0.4 mile south of Brooks it forms a shaly cliff, 30 feet thick at elevation 1425′ B.; and farther down the same stream it may be noted at different points along either side of the river. On Mill Creek between Green Sulphur Springs and Elton there are several good exposures slightly above drainage and on the same stream just north of Elton it makes a 30-foot reddish-brown, shaly cliff at elevation 1755′ B. On Lick Creek there are also several good exposures in the vicinity of Grapevine School, and on Duncan Branch of this creek it is visible 1.3 miles east of Green Sulphur Springs, being 5 feet thick and massive at elevation 1725′ B., the interval of its base below the base of the Upper Bellepoint Sandstone being 60 feet.

In Mercer County no special study of the stage where this ledge belongs was made after its large territorial extent in the Hinton region had been determined. Its further tracing should not be difficult, however, if the strata between the Upper Bellepoint Sandstone and Stony Gap Sandstone are all studied as an associated stage in which the Upper Bellepoint appears as a bold upper cliff followed by two cliffs of similar color and character except that both are thinner and much less prominent, these being the Middle and Lower Bellepoint, and finally followed below by the white and massive Stony Gap Sandstone.

So far as known the Middle Bellepoint Sandstone has not been quarried and in general it would not be suitable for building purposes, because of its shaly character, although there are doubtless a few exposures where it becomes firmer and could be locally used.

MIDDLE BELLEPOINT LIMESTONE.

The **Middle Bellepoint Limestone** (new) is a lenticular, calcareous stratum coming just a few feet under the Middle Bellepoint Sandstone, from the association with which it derives its name. When present it is usually yellow and shaly, with a thickness seldom exceeding three feet. Its type locality is in Summers County in the vicinity of Hinton, Avis, and Bellepoint, the stratum being well exposed on the Keeney Mountain road east of Hinton, where, as recorded in the Hinton Section, page 247, it is yellow, shaly, and three feet thick at elevation 1545′ B., and carries marine fossil fragments, being separated from the Middle Bellepoint Sandstone by 7 feet of red and variegated shale. It is also recorded in the Tallery Mountain Section of Chapter V, where it is yellow and 1½ feet thick. In the northern end of the county the following exposure was noted on the north side of Lick Creek two miles northeast of New Richmond.

	Feet.
Sandstone, Middle Bellepoint, shaly cliff.....	10
Shale, red	7
Limestone, Middle Bellepoint, shaly (1465′ B.)..	3

In Mercer and Monroe Counties no exposure of the Middle Bellepoint Limestone was noted. No collection of its marine fossils was made at any locality.

MIDDLE BELLEPOINT SHALE.

The **Middle Bellepoint Shale** (new) is a persistent bed that occupies the interval between the Middle and Lower Bellepoint Sandstones except when the Middle Bellepoint Limestone is present and separates it from the former sand-

stone. It is often red and variegated but at some localities it is greenish-gray and sandy with occasional streaks of limestone, its usual thickness being 25 to 40 feet. At some localities it carries marine fossils among which pelecypods and ostracods have been noted, and it also has occasional plant fossils. Its type locality is in Summers County in the lower slope of Keeney Mountain 0.2 mile north of Bellepoint, as exhibited in Local Measurement at **Fossil Lot 183 on Map VI,** page 361. Here it occurs at elevation 1518′ B. and it is only two feet thick but contains marine fossils, principally pelecypods, a collection of these having been made by the writer. Their identification by Dr. Girty appears in Chapter XVIII. In the Tallery Mountain Section, page 269, there is a good exposure of this shale just south of True where there is a marine zone of abundant ostracods coming 7½ feet below the top of the shale. Here **Fossil Lot 202 on Map VI** was collected by Dr. Girty and the writer, the discussion of which by the former appears in Chapter XVIII. Slightly below the ostracod zone the shale at this locality contains plant remains and **Fossil Lot 243 on Map VI** was collected by Dr. David White, Mr. Price, and the writer, the report on which by Dr. White will be found in Chapter XVII.

Elsewhere in Summers County the Middle Bellepoint Shale is recorded in the sections of Chapter V for Alderson, Bellepoint, Bertha, Green Sulphur Springs, Hinton, and New Richmond. In Mercer County and along a portion of the Hurricane Ridge Syncline of Monroe County this shale appears to be present, although sufficient study of it was not made to separate it definitely from the other members of the Bellepoint stage. In the northern edge of Giles County, Virginia, however, where this county wedges between Mercer and Monroe, the shale was observed in the cut of the Virginian Railway about one-third mile north of Rich Creek Station, having there an almost vertical position and being 20 feet thick and calcareous, as exhibited in the Local Measurement at **Fossil Lot 253 on Map II,** published on a subsequent page under the description of the Lower Bellepoint Shale.

LOWER BELLEPOINT SANDSTONE.

The **Lower Bellepoint Sandstone** (new) is a greenish-gray or reddish-brown, shaly ledge, 15 to 25 feet thick, having its base 50 to 75 feet below the base of the Middle Bellepoint Sandstone and 440 to 775 feet below the base of the Avis Limestone, depending on the southward expansion. This sandstone frequently makes a line of weak, discontinuous cliffs similar to those formed by the Middle Bellepoint Sandstone, both of them being much less prominent than the frequently heavy ledge of the Upper Bellepoint Sandstone farther up and the bold cliff of the Stony Gap Sandstone farther down. Its type locality is in Summers County in the vicinity of Bellepoint, as partly exhibited in Local Measurement at **Fossil Lot 183 on Map VI,** page 361, on the south slope of Keeney Mountain 0.2 mile north of Bellepoint, and as again visible near the base of Wolf Creek Mountain in the road just south of Bellepoint, as published in the Bellepoint Section, page 250. Here it is 10 feet thick at elevation 1455′ B., somewhat shaly and separated from the Middle Bellepoint Sandstone by 40 feet of shale. Elsewhere in Summers County it is recorded in the sections of Chapter V for Alderson, Bertha, Indian Mills, Hinton, and New Richmond. Along New River between Hinton and Sandstone it makes numerous cliffs but is much less prominent than the Stony Gap which may frequently be observed as the next definite ledge below it.

In Mercer County this sandstone was not sufficiently studied for identification but in the New River Valley it was noted in the northern end of Giles County in the cut of the Virginian Railway one-third mile north of Rich Creek Station, being there in a vertical position and shaly, ripple-marked, partly red and partly green, and 15 feet thick, as exhibited in the Local Measurement at **Fossil Lot 253 on Map II** published on a subsequent page under the description of the Lower Bellepoint Shale. In Monroe County it was noted on the west side of Crooked Run one mile north of Peterstown at elevation 1820′ B., being massive, coarse, 10 feet thick, and coming 30 feet above the top of the Stony Gap Sandstone.

So far as known this ledge has not been quarried and in general it probably would not give satisfaction for building purposes, owing to its shaly character, but there are doubtless local exposures where it might be used for small structures.

LOWER BELLEPOINT SHALE.

The **Lower Bellepoint Shale** (new) is a red, argillaceous and variegated, or greenish-gray and sandy deposit, commonly 30 to 40 feet thick, and coming just under the Lower Bellepoint Sandstone, and frequently carrying plant and marine fossils among which latter pelecypods, brachiopods, and fish remains have been noted. Its type locality is in Summers County in the vicinity of Bellepoint, there being a good exposure in the road which ascends Wolf Creek Mountain just southeast of the town at elevation 1425′ B. Here, as exhibited in the Bellepoint Section, page 250, it is green, sandy, and 35 feet thick, there being marine fossils in the upper part among which are pelecypods and ostracods. **Fossil Lot 200 on Map VI** was collected by the writer at this locality, the identifications of which by Dr. Girty will be found in Chapter XVIII.

Elsewhere in Summers County this shale is recorded in the sections of Chapter V for Alderson, Bertha, Hinton, Indian Mills, and New Richmond, its thickness varying from 15 to 49 feet. It may also be conveniently observed at several points along New River between Hinton and Sandstone, coming between the Lower Bellepoint and Stony Gap Sandstone ledges. Farther southeast it outcrops on either side of Greenbrier and New Rivers but gradually ascends to higher levels on account of the southeastward rise of the rocks and must usually be sought along the upland roads.

In Mercer County it may be seen at numerous exposures just above the Stony Gap Sandstone and on Bluestone River the following outcrop was noted just across the State line in Tazewell County, Virginia:

PLATE XX.—Alderson Limestone in axis of Abbs Valley Anticline on Sandlick Creek 0.7 mile northwest of Sandlick, Mercer County, looking northeast. The unsymmetrical nature of the fold is plainly visible. (Photo. by Palmer & Fowler).

Local Measurement at Fossil Lot 209.

Tazewell County, Virginia; in upper highway west of Bluestone River at Flattop Yards 0.2 mile southwest of State line; dip, southeast; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (36′)			
1.	**Shale, Lower Bellepoint,** sandy (2370′ B.); contains marine fossils, pelecypods and a few brachiopods (see **Lot 209**)	5	5
2.	Slate, black	1	6
3.	**Shale, Lower Bellepoint** (continued), sandy, with plant fossils, to road	5	11
4.	**Sandstone, Stony Gap (Hinton** of Stevenson), gray, massive, coarse, quarry rock	25	36

At the above locality Dr. Girty and the writer collected **Fossil Lot 209 on Map II,** the discussion of which by the former will be found in Chapter XVIII.

In the northern end of Giles County, Virginia, where it wedges between Mercer and Summers Counties in the New River Valley, the following local measurement was obtained, exhibiting the southward expansion that has taken place in this portion of the Hinton Group:

Local Measurement at Fossil Lot 253.

Giles County, Virginia; in Virginian Railway cut on east side of New River 0.2 mile north of Rich Creek Station; rocks slightly overturned but nearly vertical; arrangement in descending stratigraphic order from north to south.

		Thickness. Feet.		Total. Feet.
Mauch Chunk Series—Hinton Group (213′)				
1.	**Shale, Middle Bellepoint,** calcareous	20		20
2.	**Sandstone, Lower Bellepoint,** partly red and partly green, shaly, ripple-marked	15		35
3.	Shale, gray, calcareous	15′		
4.	Shale, sandy	10		
5.	**Coal, streak (0′ 1″)**	..		
6.	Sandstone, hard, flaggy	5		
7.	Shale, greenish-gray, sandy	5		
8.	Limestone, gray, shaly, and impure, contains numerous marine fossils, brachiopods (including **Orthotetes**), and pelecypods	5		
9.	Shale, gray, calcareous	20	**Lower Bellepoint Shale**	118
10.	Shale, red and variegated	10		153

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
11.	Sandstone, shaly, to Mile-Post No. 321.....	5		
12.	Shale, red and green.....	7½		
13.	Sandstone, calcareous (1530′ B.); contains marine fossils, ostracods in great profusion and fragments of fish teeth (see Lot 253).....	0½		
14.	Slate, black, coaly.....	1		
15.	Shale, red and variegated.	15		
16.	Sandstone, shaly.....	4		
17.	Shale, red.....	15		
18.	Sandstone, massive, hard, tinged with red.....	15′		
19.	Shale, green, sandy.....	10		
20.	Slate, black, streak..... ..		Stony Gap Sandstone	60 213
21.	Sandstone, massive, hard.	15	(Hinton of	
22.	Shale, red, and sandstone, hard, distorted and crushed together.....	20	Stevenson.)	
Mauch Chunk Series—Bluefield Group (236′)				
23.	Shale, red, contains marine fossils, ostracods..	15′		
24.	Sandstone, calcareous, with marine fossils.....	1	Coney Shale.....141	354
25.	Shale, red and variegated, with streaks of lime....	125		
26.	Sandstone, Clayton, shaly.....		10	364
27.	Shale, green and red, sandy	15′		
28.	Sandstone, shaly.....	10	Clayton Shale.... 75	439
29.	Shale, very sandy.....	50		
30.	Sandstone, Graham, gray, hard, at end of cut 200 feet north of mouth of Rich Creek.....		10	449

At the above locality, which is at a very convenient point and well worth additional study, it is quite evident to an observer on the ground that only a few thin streaks of thin or shaly sandstone occur within Nos. 3-17 of section, while just to the north in these vertical exposures No. 2, with its red and green color, is highly suggestive of the Lower Bellepoint Sandstone, Nos. 18-22, cropping just south of the shales and consisting of three beds of massive and very hard sandstone, apparently represent the Stony Gap Sandstone which has been locally split into benches, having lentils of shale and black slate as is not uncommon in the more southwestern counties of Virginia. Just southward along the railroad the upper members of the Bluefield Group appear in regular order

until the end of the cut is reached near the mouth of Rich Creek. The Lower Bellepoint Shale itself is invaded by streaks of coal and coaly slate and by calcareous matter and streaks of sandstone. In one of the sandstone zones (No. 13) Mr. Price and the writer collected **Fossil Lot 253 on Map II,** there being numerous ostracods, and fragments of fish teeth, as identified more in detail by Dr. Girty in Chapter XVIII.

In Monroe County the Lower Bellepoint Shale outcrops along the Hurricane Ridge Syncline between Peterstown and Rock Camp Creek, the following being one of its partial exposures:

Local Measurement at Fossil Lot 254.

Red Sulphur District, Monroe County; in hill road at head of Mud Run of Rich Creek, 1.1 miles west of Lindside; dip, southward 15°; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (11′)		
1. **Shale, Lower Bellepoint,** green	5	5
2. Limestone, part of **Lower Bellepoint Shale** (continued), siliceous, with comminuted structure (2085′ B.); contains marine fossils, one supposed fish tooth but reported as nothing determinable (see **Lot 254**)	1	6
3. **Shale, Lower Bellepoint** (continued), sandy	5	11
4. **Sandstone, Stony Gap (Hinton** of Stevenson), massive	..	..

At the above locality **Fossil Lot 254 on Map IV** was collected by Mr. Price and the writer, there being some imperfect marine fossil fragments, one of which had the appearance of a fish tooth, but Dr. Girty in a preliminary list reports nothing determinable, his final conclusion being published in Chapter XVIII.

STONY GAP SANDSTONE (HINTON of Stevenson).

The **Stony Gap Sandstone** (new) is the basal member of the Hinton Group. In a paper prepared many years ago this ledge was called the **Hinton Sandstone** by Dr. John J. Stevenson from its exposure in the vicinity of Hinton, Summers County, but no further use appears to have been made of this

name and in 1896 Campbell[13] employed the term "Hinton" for a major subdivision of the outcropping rocks of the New River Valley. This latter usage has become so well fixed in the literature of West Virginia and Virginia that it now appears impossible to revert to the earlier application without needless confusion. In 1916, however, the name "Hinton" was applied by Krebs[14] to a brown sandstone on the road ascending Whiteoak Mountain just northwest of Hinton and having its base 40 feet above the level of New River. A careful investigation of this locality by the writer reveals the fact that the top of the Stony Gap Sandstone (Hinton of Stevenson) is only 25 feet above the bed of New River at the base of Mr. Krebs' section, since there is a rapid northwestward dip which carries the rock to a much lower level than its position in the Chesapeake and Ohio Railway cut on the east side of the river near the station. Allowing for the dip from the top of the Stony Gap Sandstone to the base of the rock described as Hinton in the Krebs' section the actual interval between these two formations would be about 25 feet and the upper bed which is there quite shaly, would belong at the horizons of the Lower Bellepoint and Middle Bellepoint Sandstones of the present Report, which it much resembles in sharp contrast to the white and quartzitic character of the Stony Gap (Hinton of Stevenson).

The **Stony Gap Sandstone,** as above defined, is a light-gray or white, massive, coarse, and extremely hard and quartzitic ledge, usually varying in thickness from 35 to 85 feet. It is almost totally devoid of quartz pebbles but in the valley of New River between the mouth of the Greenbrier and Sandstone Falls there is a deposit of shale breccia at its base which may perhaps properly belong to the sandstone although it is sometimes separated from it by a thin bed of red shale. The type locality of the Stony Gap Sandstone is at the village of Stony Gap, Mercer County, where the rock is well displayed on either side of the Bluefield-Princeton road, its position

[13]M. R. Campbell, Pocahontas Folio, No. 26, U. S. Geol. Survey; 1896.

[14]C. E. Krebs, Raleigh County and Western Portions of Mercer and Summers Counties Report, W. Va. Geol. Survey, p. 77; 1916.

being almost vertical but slightly overturned so that it now dips southeastward 70 degrees. Here, as recorded in the Stony Gap Section, page 197, it is 115 feet thick, white, hard, and quartzitic, but not pebbly, and contains plant fossils near its base. **Fossil Lot 235 on Map II** was collected at this point by Dr. David White, Mr. Price, and the writer, as enumerated and discussed by Dr. White in Chapter XVII. Plate XI shows an excellent view of this typical exposure.

From Stony Gap southwestward the Stony Gap Sandstone makes the core of Stony Ridge practically all the way to Bluestone River in the edge of Tazewell County, Virginia, as already mentioned by Campbell in Folio 26, where this ledge was well described although not given a specific name. At Bluestone River, however, it is locally broken and disturbed by the Stony Ridge Fault, as described on page 180. Plate XIII shows a view of the outcrop in Stony Ridge as seen from Bluefield, the jagged nature of the reef being plainly evident.

Northeast of Stony Gap the outcrop continues in the same ridge to the point where Twelvemile Creek cuts through the topography and exposes the rock at drainage, being 50 feet thick and overturned, with a present southward dip of 80 degrees. Continuing northeastward in the line of broken hills that represent the extension of Stony Ridge it is again visible along the Princeton-Narrows road on Fivemile Creek one-half mile northeast of Oakvale and just north of the East River District High School, being 75 feet thick with 10 feet of shale near the middle and having plant fossils near the base, the present angle of its overturned position being 60 degrees southeastward. Farther on it passes into Giles County, Virginia, just north of Glenlyn; and in the same county is well displayed in the cut of the Virginian Railway just north of the mouth of Rich Creek, as exhibited in Local Measurement at **Fossil Lot 253 on Map II**, pages 369-70, being 60 feet thick but split by shale and slate.

On the south side of the Abbs Valley Anticline the Stony Gap Sandstone is visible on the west side of Bluestone River at Flattop Yards, Tazewell County, Virginia, just west of the

Mercer line, as recorded in Local Measurement at **Fossil Lot 209 on Map II,** page 369, and from this point northeastward it makes an outcrop 13 miles long, being especially prominent on the slope south of Blackoak Mountain northeast of Sandlick village and finally passing under the topography of the ridge and anticline just northeast of the road which crosses from Princeton to Kegley. In the vicinity of this road crossing it passes around to the northern limb of the anticline and makes a like outcrop southwestward to the Virginia line, except that it is much more spectacular than on the south side because of its nearly vertical position. Along this extent it may be viewed at almost any of the minor tributaries of Bluestone River that originate on the north side of Blackoak Ridge or cut through this topography en route to the parent stream. At the Pinnacle Rock, slightly southeast of Simmons, it makes a huge vertical cliff in the top of a ridge, as exhibited by Plate XII.

In Monroe County on the south side of the Hurricane Ridge Syncline the Stony Gap Sandstone makes the almost vertical reef of Chimney Ridge and of the numerous shorter ridges that comprise its northeastward extension, being well displayed in the gaps made between them by several streams in the region north of Brick Church and Lindside, its position being usually nearly vertical and often overturned. On the west side of Rock Camp Creek, however, where the rocks have assumed a more normal bedding this ledge belongs high up in the ridge and its outcrop passes to the northern limb of the syncline and farther west it is the principal bed that holds up the plateau surface of the ridges in the vicinity of Orchard, Cashmere, Cloverdale, Ballard, and Chestnut Hill, but at the latter two points it reaches the crest of the Abbs Valley Anticline from which it dips gently northwestward into Summers County as indicated by the geologic maps, its base being coincident with the base of the Hinton Group. Farther north, across the deep valley of Indian Creek, it occurs again in the tops of the ridges in the neighborhood of New Hope School, High Top, Milton Hall School, and Lively

School. In the same county it is exhibited in the Red Sulphur Springs Section, page 218.

In Summers County its position and thickness are recorded in the sections of Chapter V for Alderson, Bellepoint, Bertha, Glenray, Hinton, Indian Mills, Marie, New Richmond, Pence Springs, Talcott, Tallery Mountain, and Warford. On New River its top comes above drainage in the vicinity of Farley Creek and at New Richmond it is fully above the level of Lick Creek and makes a huge cliff which becomes even thicker at Sandstone where the following exposure is visible at the mouth of Laurel Creek:

	Feet.
Sandstone, Stony Gap, massive, great cliff.....	85
Sandstone, Stony Gap (continued), very hard but brecciated, with siliceous matrix and many included green shale particles (1290′ B).....	35
Limestone, Coney, shaly.....	4
Sandstone, red.....	2
Shale, red, calcareous, to creek and river.....	6

About one mile farther south and upstream almost the same exposure is visible at Sandstone Falls, the cataract itself being made by 25 feet of the gnarly and shaly breccia which there has almost the hardness and durability of Portland cement. From the falls southward for about four miles the main sandstone ledge remains above drainage, its thickness varying from 50 to 75 feet, but at the base there are green and red shales instead of breccia, so that the latter has apparently thinned out and disappeared or else has become separated from the main ledge by a shale parting, there being no exposure sufficiently deep in the strata to determine which is actually the case.

About one-half mile northwest of Brooks the base of the sandstone goes under drainage and at the Springdale Syncline just south of Brooks the entire member is submerged but just north of Tug Creek its top again rises into view and in the northern suburbs of Hinton the whole ledge is again revealed and it gradually rises until it reaches the axis of the Dunn Anticline between Avis and Bellepoint, its base being about 70 feet above the river. In this locality it is underlaid by the Coney Limestone and Coney Shale, there being no trace of the breccia. Plate XIV exhibits its appearance along the Chesa-

peake and Ohio Railway just south of Hinton, a large portion of the business part of the city being built on a gravel terrace which is mainly upheld by this massive bed, as is more evident in Plate VI.

From the Dunn Anticline southward the rock again descends, its base being only 20 feet above the river at Bellepoint. Here a recurrence of the shaly breccia may be observed in Greenbrier River near water-level and just east of the highway bridge. Above Bellepoint the ledge soon goes under the bed of New River along the Bellepoint Syncline, as has been proved by numerous exploratory diamond drill borings recently made by the West Virginia Power Company, but about one mile south of the mouth of Bluestone River its base again comes above drainage and so remains all the way to the Virginia State line, but in the region between Bluestone River and Indian Creek it is quite inconspicuous, having become so shaly or thin that it may be recognized only by interval from other formations. At Mercers Salt Works it has again become a huge 50-foot cliff, about 115 feet above the river, there being a rapid rise from this point southward to the Abbs Valley Anticline where it crowns the high plateau along the Summers-Monroe line, as previously described.

On Indian Creek the Stony Gap Sandstone is high up in the hills and only weakly developed, but at Marie, near the head of Bradshaw Creek, it has regained its usual character and forms the plateau on which the village is built.

On Greenbrier River it is below drainage or covered in the flood-plain at the Bellepoint Syncline just east of Bellepoint but wholly emerges in the vicinity of Browning and then gradually rises, making a great cliff above the Chesapeake and Ohio Railway just west of Powley Creek, its top being at elevation 1625′ B., while on the opposite side of the river the ledge is just beneath the county road nearly all the way from Cave Branch to Woodramtown Branch. South of Hilldale it occurs in the terrace lands of the Big Bend and just northeast of the mouth of Big Bend Tunnel it is visible in the Hinton-Talcott road, as recorded in the Talcott Section, page 251. East of Talcott it is wholly above the topography on the south side

of the river but on the north side it occurs in the spurs of Keeney Mountain, being noted in the Alderson Section at the head of Possum Hollow, but being much less prominent than at Hinton.

In its more extended relationships the Stony Gap Sandstone may be readily traced southwestward in Virginia through Tazewell, Russell, Scott, Wise, and Lee Counties to Cumberland Gap which is 135 miles from the type locality, but in Tazewell County it splits into two distinct benches and at Pennington Gap there are three separate ledges of white sandstone that may all belong to its horizon, while at Cumberland Gap it is represented by a single bed. Southwest of Cumberland Gap it disappears along with the majority of the other members of the Hinton Group.

Northeastward from the type locality it may be traced to the head of the Greenbrier River, beyond which it declines in importance with all the remainder of the Mauch Chunk Series in northern West Virginia and Maryland. In northeastern Pennsylvania, however, where the Mauch Chunk again reaches the approximate thickness found in southern West Virginia, there is visible near Tamaqua, Schuylkill County, a huge gray sandstone carrying quartz pebbles and coming 815 feet above the base of the Mauch Chunk. The character and stratigraphic position of this ledge, which contrasts so sharply with most of the shaly red beds of the series in that region, is so much in harmony with the Stony Gap that a correlation is immediately suggested although such may be difficult of proof. At Mauch Chunk the same sandstone reappears within the city on the south side of Lehigh River just opposite the Lehigh Valley Railroad Station. It is hoped to publish the details of these two most interesting sections in a later volume.

At the **Pat Rohr Quarries,** in Stony Ridge north of Bluefield, the Stony Gap Sandstone has been extensively quarried for building stone for local use in Bluefield. One of these quarries is located on the south side but near the top of the ridge 0.6 mile northeast of Bluefield Station and one-fourth mile southwest of the highway which crosses the ridge, the elevation of the quarry base being 2840′ B. Here the rock

is overturned and now dipping southward 57 degrees, being grayish-white, hard, and coarse but much broken and irregular, most of the joint-planes being slickensided by the lateral thrust which overturned the strata.

Another quarry on the same property is located 0.5 mile due north of Bluefield Station, 0.3 mile northeast of the highway across the ridge and just east of the electric sign-board of the Appalachian Power Company, its base being at elevation 2815′ B., and just south of the crest of the ridge. Here the rock is grayish-white, massive, and hard but contains some softer streaks and some bands of iron oxide, the present dip of the overturned strata being 69 degrees southward.

Although not at present active these two quarries have afforded a large amount of stone for use around Bluefield. The product is so hard as to be practicably indestructible but there is difficulty in splitting it into suitable blocks and it can scarcely be cut on account of its hardness. When once quarried and in place, however, its suitability for severe usage is well attested by its behavior in structures in the vicinity of the railroad yards where it is highly resistive against the disintegrating effect of train smoke. In Plate XIII the first of the above-described quarries is plainly visible in Stony Ridge, the other being obscured by foliage.

DESCRIPTION OF MEMBERS, BLUEFIELD GROUP OF MAUCH CHUNK SERIES.

In the Bluefield Group of the Mauch Chunk Series only a few members have been previously named in the surrounding territory where correlations may safely be made with the formations of the three counties. As far as is now prudent these few titles are recognized in the present Report but in some cases it has seemed necessary to give them second place in order to be more certain of the definite relationships. Members not previously named are assigned titles with the parenthetic explanation that they are new. In the lower 400 feet of the Bluefield Group, however, it is quite evident that there is a very great similarity both in physical characteristics and

in faunal assemblages when compared with the standard column of the Chester Series in western Kentucky, Missouri, and Illinois, where these formations have been long ago studied and described, and in some cases the writer believes that the western names might be adopted with much assurance, but the propriety of correlating minor subdivisions across the hiatus of several hundred miles caused by the intervention of the Cincinnati Anticline might well be questioned. Under these circumstances the members in this portion of the group, also, have been assigned West Virginia titles, but at the same time a comparison of their age with that of the western column has been indicated, in the view that less violence will be done to traditional caution and that some mistakes may possibly be avoided. The upper 900 feet of the group, however, including the Droop Sandstone, do not appear to be represented in the West so that no correlation in that portion may be even suggested.

CONEY LIMESTONE.

The **Coney Limestone** (new) is the upper member of the Bluefield Group of the three counties, its position being just below the great Stony Gap Sandstone. As a rule it is greenish-yellow, shaly, and lenticular, being 3 feet or less in thickness and containing occasional marine fossils. Its type locality is in Summers County on the east side of New River in the vicinity of Avis and just opposite Coney Island, as indicated in the Hinton Section, page 248. Here it is shaly and two feet thick and belongs about 40 feet above the Chesapeake and Ohio Railway. Elsewhere in Summers County it is noted in the sections for New Richmond, page 244, and Indian Mills, page 265. On New River it was noted at the mouth of Laurel Creek just south of the village of Sandstone, as published in a local observation at that point in connection with the Stony Gap Sandstone, page 375, and about one mile farther south and just northeast of Sandstone Falls it is again visible beneath the brecciated basal portion of the Stony Gap Sandstone, as exhibited in the following observation:

		Feet.
1.	**Sandstone, Stony Gap,** somewhat shaly; makes a great overhanging cliff	65
2.	**Sandstone, Stony Gap** (continued), gnarly and filled with green shale breccia, falls rock (1310′ B.)	25
3.	**Limestone, Coney,** very shaly and sandy	4
4.	Sandstone, red, shaly	3
5.	Shale, reddish, calcareous, to grade	5

At **Fossil Lot 185 on Map VI** in Talcott District on a hill road in the Big Bend of Greenbrier River 1.2 miles west of Boone School and 1.1 miles south of Hilldale, collected by the writer, this limestone is yellow, shaly, and five feet thick at elevation 1715′ B., and contains brachiopods, as discussed in more detail by Dr. Girty in Chapter XVIII.

In the extreme southern end of the county this limestone was noted on Lick Creek 0.8 mile southwest of Mercers Salt Works coming beneath the Stony Gap cliff at elevation 1530′ B.

CONEY SHALE.

The **Coney Shale** (new) is a red, variegated, and sandy deposit coming just below the Coney Limestone, or, when that member is absent, just below the Stony Gap Sandstone, varying in thickness from 40 to 70 feet. At various points it carries marine fossils among which ostracods are especially numerous, and pelecypods, including **Myalina,** and brachiopods, gastropods, and cephalopods have been noted, the ostracods being usually found in the red or greenish and argillaceous portions. It also contains a very well-defined and persistent plant fossil zone in which **Bothrodendron** is prominent. Its type locality is in Summers County on the east side of New River just east of Avis and just opposite Coney Island, as recorded in the Hinton Section, page 248. Here it contains green, sandy shale with marine fossils, and red, variegated, and sandy shale with a zone of plant fossils, from which Dr. David White, Mr. Price, and the writer collected **Fossil Lot 244 on Map VI** as will be enumerated and discussed by Dr. White in Chapter XVII.

At this point the shale contains some incrustations of green, crystalline copper ore too insignificant to be of commer-

cial value but having a scientific interest, and it also holds some vermilion-colored or red incrustations suggestive of chromium, but a sample (No. 642R) is reported by Mr. Kaplan as being red hematite with no chromium.

Elsewhere in Summers County the shale is recorded in the sections of Chapter V for Alderson, Bertha, Glenray, Indian Mills, Marie, New Richmond, Pence Springs, and Talcott.

At **Fossil Lot 225 on Map VI,** collected by Dr. Girty and the writer on the Hinton-Talcott road just northeast of the eastern portal of the Big Bend Tunnel as indicated in the Talcott Section, page 251, the shale contains abundant small pelecypods, suggesting **Sphenotus,** as discussed by Dr. Girty in Chapter XVIII. A later visit to this locality by Mr. Price and the writer revealed the presence of ostracods, also, but no collection of them was made. At **Fossil Lot 221 on Map VI,** collected by Dr. Girty and the writer on the east side of Hungard Creek one-half mile south of Clayton, as recorded in the Pence Springs Section, page 253, the shale contains pelecypods, chiefly **Myalina,** ostracods, and annelids **(Spirorbis),** as enumerated and discussed by Dr. Girty in Chapter XVIII, and there are also fucoidal markings.

In Mercer County the Coney Shale is well displayed in the Stony Gap Section, page 197, being 95 feet thick and containing marine fossils in the upper 10 feet as collected by Dr. Girty and the writer in **Fossil Lot 207 on Map II,** and having pelecypods (mostly **Myalina)** and abundant ostracods as discussed by Dr. Girty in Chapter XVIII. In the edge of Tazewell County, Virginia, the shale is exposed in the road 0.7 mile northeast of Flattop Yards and just north of the crest of the ridge, being 30 feet thick at elevation 2460′ B., and containing **Bothrodendron,** as observed by Mr. Price and the writer. On Fivemile Creek, Mercer County, 0.4 mile northeast of Oakvale and just north of the East River District High School, it is exposed just south of the Stony Gap Sandstone reef, its red beds containing pelecypods and ostracods and also plant fossils. In Giles County, Virginia, it is visible on the west side of New River just north of Glenlyn and contains ostracods;

and in the same county it is well displayed at **Fossil Lot 253 on Map II** in the cut of the Virginian Railway just north of the mouth of Rich Creek, having a total thickness of 141 feet, with ostracods in the upper 15 feet and with other marine fossils, as recorded in the local measurement at this point, page 370.

In Monroe County it is exhibited in the Red Sulphur Springs Section, page 218, and there contains marine fossils among which pelecypods were observed, and at a later visit a leaf of **Bothrodendron** was noted by Mr. Price and the writer. Its presence is also recorded in the section for Wikel, page 220; and in the eastern part of the county its upper portion is displayed at the following locality:

Local Measurement at Fossil Lot 161.

Red Sulphur District, Monroe County; in bluff on west side of Brush Creek 0.7 mile northeast of Peterstown; dip, southeast 5°; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (61′)		
1. **Sandstone, Stony Gap (Hinton of Stevenson),** massive, coarse, great cliff (1700′ B.)	50	50
2. **Shale, Coney,** green, sandy, with marine fossils	5	55
3. **Shale, Coney** (continued), green, with plant fossils.	2	57
4. Limestone, siliceous (0′ 6″)	0½	57½
5. **Slate, Coney** (continued), dark, carbonaceous, with plant and marine fossils. Collection of marine fossils from Nos. 2 and 5 of section; contains pelecypods (chiefly **Myalina**) and ostracods (see **Lot 161**).	1	58½
6. Sandstone, shaly, to Brush Creek	2½	61

Fossil Lot 161 on Map IV was collected at this point by the writer, the fauna being described in more detail by Dr. Girty in Chapter XVIII. A later visit was made to this locality by Dr. David White, Mr. Price, and the writer in the hope of obtaining plant fossils but the specimens proved to be too fragmentary for identification and no collection was made.

Farther east it is visible on the ridge one mile northeast of Brick Church, being red and variegated and containing marine fossils among which pelecypods were noted at elevation 2025′ B.

The red and variegated portions of this shale should make good building brick and there are many points in the three counties where they could be easily quarried.

CLAYTON SANDSTONE.

The **Clayton Sandstone** (new) is the first heavy-bedded rock below the Stony Gap Sandstone, being separated from that ledge by the Coney Limestone and Coney Shale as above described. As a rule it is reddish-brown, fine-grained, smooth-textured, medium-hard, and thick-bedded, and varies in thickness from 20 to 30 feet. Its type locality is in Summers County on the waters of Griffith Creek on the road which descends into this valley 1.2 miles northeast of Clayton, at elevation 2050′ B.

In the **Alderson Brownstone Quarry** at the above described type locality this sandstone was extensively quarried but the plant has not been active for several years. At this point the rock is 30 feet thick with the same physical characteristics as above noted, the quarry face being 200 feet long and extending 75 feet into the hill, and embracing the entire thickness of the stone. The product is reported to have been shipped to Richmond, Virginia, and other points and for paving block and general building stone, there being a considerable quantity of paving blocks still on hand at the quarry and affording evidence in this particular. Plate XV shows a good view of this quarry.

Elsewhere in Summers County the Clayton Sandstone is recorded in the sections of Chapter V for Indian Mills, Marie, Pence Springs, and Talcott. In the northern part of the county it does not outcrop but on Greenbrier River and on New River above the mouth of Bluestone it may frequently be noted. On the road from Wolf Creek to Wolf Creek Mountain 1.5 miles west of Buck it is 25 feet thick and shaly, its top being at elevation 1770′ B. On the upland road one-half mile northeast of Forest Hill it is 20 feet thick and massive, its top being at elevation 1945′ B. On the road south of Stony Creek 1.3 miles southwest of Ballengee it is massive and 40

feet thick, the elevation of the top being 1825′ B. On the south side of Cedar Branch of New River 0.9 mile southwest of Mandeville it makes a massive cliff 30 feet thick with a basal elevation of 1765′ B.

In Mercer County this sandstone is recorded in the Stony Gap Section, page 197, as five feet thick and massive; and elsewhere in the county it may be observed at various points, being easily identified from its relationship to the Stony Gap Sandstone above it. In the gap which Twelvemile Creek makes through Stony Ridge 0.5 mile northwest of Ingleside it makes an almost vertical reef 20 feet thick, and about 50 feet south of the reef made by the Stony Gap. In Giles County, Virginia, it is visible in the Virginian Railway cut on the east side of New River just north of the mouth of Rich Creek, being shaly and 10 feet thick as recorded in the local measurement at **Fossil Lot 253 on Map II,** page 370.

In Monroe County the Clayton Sandstone is recorded in the Red Sulphur Springs Section, page 219, where it is 15 feet thick, reddish-brown, and flaggy, and in that for Wikel, page 220, it is 25 feet thick and rather soft. It may also be observed at various other points.

In localities where this sandstone is firm and durable and has its typical reddish-brown color it is capable of extensive development as a building stone, since its general texture is unusually pleasing and it may be quarried and worked without difficulty. From this viewpoint it is worthy of serious consideration.

CLAYTON SHALE.

The **Clayton Shale** (new) is a red and variegated or greenish deposit, coming just under the Clayton Sandstone and usually varying in thickness from 50 to 80 feet and having occasional marine fossils, mostly pelecypods of the genus **Sphenotus.** Its type locality is in Summers County on the road descending into the valley of Griffith Creek 1.2 miles northeast of Clayton, as recorded in the Glenray Section, page 255, where it is 95 feet thick and variegated in color but mostly

red, and carries marine fossils in the upper portion. **Fossil Lot 245 on Map VI** was collected by Mr. Price and the writer from a zone 10 to 20 feet below the top of the shale at this point, the fauna being mostly pelecypods, among which **Sphenotus** predominates, as listed in more detail by Dr. Girty in Chapter XVIII. Elsewhere in Summers County it is recorded in the sections for Alderson, Indian Mills, Marie, Pence Springs, and Talcott.

In Mercer County it is noted in the Stony Gap Section, page 197, as 95 feet thick, red and variegated, and at many other points, also, in the same county it may be observed.

In Monroe County it is exhibited in the sections for Red Sulphur Springs and Wikel; and at **Fossil Lot 164 on Map IV** on the road which ascends Lowell Branch of Indian Creek 0.7 mile southeast of Marie a collection was made by the writer as recorded in the Marie Section, page 266. Here it contains numerous marine fossils, among which pelecypods, brachiopods, and gastropods were noted, as listed in detail by Dr. Girty in Chapter XVIII. On the mountain road toward Milton Hall School at the head of Indian Draft 0.3 mile southwest of Wayside it is green in color at elevation 2030′ B., and contains marine fossils, both pelecypods and large brachiopods.

In Giles County, Virginia, it is well exposed in the vertical beds of the Virginian Railway cut just north of the mouth of Rich Creek being 75 feet thick but separated into two beds by a shaly sandstone as indicated in the Local Measurement at **Fossil Lot 253 on Map II.**

This shale could be very easily utilized for the manufacture of building brick, since it is usually free from sandstone.

GRAHAM SANDSTONE.

The **Graham Sandstone** (new) is a greenish-gray ledge, usually shaly but sometimes massive, and generally varying from 15 to 30 feet in thickness, its position being just below the Clayton Shale and about 200 feet below the Stony Gap Sandstone in the region of maximum intervals. Its type locality is in the edge of Tazewell County, Virginia, in a cut

of the Norfolk & Western Railway about one-half mile northwest of the new station at Graham (now Bluefield, Virginia), as recorded in the Graham Section, page 191. Here it is shaly and 15 feet thick being inclined northwestward at an angle of about 30 degrees.

It is quite probable that this bed correlates with the Big Spruce Knob Sandstone of the writer[15], as has been indicated in the Graham Section, but it has not been sufficiently well traced to be certain that such is the case and it is therefore given a local designation until its identity with the Big Spruce Knob has been proved or disproved.

In Mercer County this ledge is again recorded in the Stony Gap Section, page 197, being 30 feet thick, green, and flaggy; and in the edge of Giles County, Virginia, it is visible in the cut of the Virginian Railway just north of the mouth of Rich Creek, being gray, hard, and 10 feet thick, as recorded in the Local Measurement at **Fossil Lot 253 on Map II.**

In Monroe County it is exposed in the sections for Red Sulphur Springs and Wikel, pages 219 and 220, respectively, being 25 feet thick, coarse, massive, and soft at the latter locality. It may also be observed at various other points in the western part of this county.

In Summers County it is noted in the sections of Chapter V for Alderson, Indian Mills, Pence Springs, and Talcott, being shaly at the latter three localities, but in the region south of the Big Bend of Greenbrier River it is visible on Spruce Run 0.9 mile above its mouth, making a massive, gray cliff 30 feet thick at elevation 1735′ B. In the same region it is exposed on Wolf Creek just east of Buck where it makes a coarse, massive cliff, 30 to 40 feet thick, the elevation of its top being 1660′ B.

At various points in the three counties this stone could be quarried for building purposes, since it is often massive and durable, but its texture is hardly suited for structures where fine architectural effects are desired.

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[15]David B. Reger, Webster Report, W. Va. Geol. Survey, pp. 221-223; 1920.

GRAHAM LIMESTONE.

The **Graham Limestone** (new), coming just under the Graham Sandstone, is usually gray and shaly with a thickness of two to three feet, although sometimes exceeding these figures, and with frequent marine fossils, these being chiefly pelecypods with occasional brachiopods and gastropods. Its type locality is in the edge of Tazewell County, Virginia, in the cut of the Norfolk & Western Railway on the southwest side of Bluestone River about one-half mile northwest of the new station at Graham. Here, as exhibited in the Graham Section, page 191, it is two feet thick and shaly, being separated from the Graham Sandstone by 10 feet of shale, and contains marine fossils. At this point Dr. Girty and the writer collected **Fossil Lot 123 on Map II**, a part of the material being from the underlying Upper Graham Shale. These fossils are listed in detail by Dr. Girty in Chapter XVIII.

In the Stony Gap Section of Mercer County, page 197, this limestone is represented by 15 feet of green, calcareous shale; and in the Lurich Section, in the edge of Giles County, Virginia, page 204, it is four feet thick, with marine fossils. In Monroe County it is recorded in the Red Sulphur Springs Section, page 219; and in Summers County it is noted in those for Alderson and Indian Mills, pages 257 and 265, respectively, being 10 feet thick at the latter locality, but very shaly.

This limestone is of interest because of its fauna but it is too shaly and siliceous to have any economic importance.

UPPER GRAHAM SHALE.

The **Upper Graham Shale** (new), coming below the Graham Limestone or in some cases just below the Graham Sandstone when the limestone is absent, is usually a gray, ferruginous, and calcareous deposit 20 to 30 feet thick and having marine fossils in its upper portion, among which pelecypods (especially **Myalina** and **Sphenotus**) and ostracods have been noted, and having plant fossils near its base. Its type locality is in the edge of Tazewell County, Virginia, in the cut of the Norfolk & Western Railway on the southwest

side of Bluestone River about one-half mile northwest of the new station at Graham. Here it is 19 feet thick as exhibited in the Graham Section, page 191. **Fossil Lot 123 on Map II** was collected by Dr. Girty and the writer partly from the upper part of the Upper Graham Shale and partly from the Graham Limestone, this fauna being listed in detail by Dr. Girty in Chapter XVIII. At this point there are four feet of dark and fissile shale at the base of the formation, containing both marine and plant fossils. **Fossil Lot 124 on Map II** was collected at this locality by Dr. David White, Mr. Price, and the writer, some of the material being from the Bertha Sandstone which there occurs 16 feet under the shale. The detailed list of these plants, as studied by Dr. White, will be found in Chapter XVII.

There is much ground for belief that the Upper Graham Shale correlates with the **Big Spruce Knob Shale** of the writer[16], which was first noted in the northwestern edge of Pocahontas County and which there also contains plant fossils of which a collection was sent to Dr. David White and proved to have **Asterocalamites scrobiculatus** (formerly **Bornia radiata**), but without further detailed study between these two widely separated localities it seems prudent to give the shale a local designation.

This shale is again well exposed in Mercer County along the Bluefield-Princeton road 0.2 mile southwest of Stony Gap and it contains both plant and marine fossils. **Fossil Lot 208 on Map II,** as collected by Dr. Girty and the writer, contains both pelecypods (especially **Myalina** and **Sphenotus**) and ostracods, as listed in more detail by Dr. Girty in Chapter XVIII. **Fossil Lot 234 on Map II** was collected from the plants by Dr. David White, Mr. Price, and the writer, as will be later described by Dr. White in Chapter XVII.

In Giles County, Virginia, this shale is noted in the Lurich Section, page 204, being 60 feet thick, and sandy, and probably combined with the Lower Graham Shale, since the intervening coal appears to be absent.

[16]Ibid., pp. 223-224.

In Monroe County the shale is noted in the sections of Chapter V for Red Sulphur Springs, and Wikel; and in Summers County it is exhibited in those for Indian Mills, Pence Springs, and Talcott. It may also be observed at numerous other points in all three counties.

GRAHAM COAL.

The **Graham Coal** (new), belonging between the Upper Graham and Lower Graham Shales, and coming nearly 250 feet below the Stony Gap Sandstone in the region of maximum intervals, is a lenticular bed occurring principally in southern Mercer County and in Tazewell County, Virginia, its thickness being usually less than two feet. It is quite probable that this coal is the same as the **Big Spruce Knob Coal** of the writer[17], as originally noted on the waters of Williams River in the northwestern part of Pocahontas County, but it has not been traced in detail through the 100 miles of distance between Big Spruce Knob and Graham so that it appears more prudent to give it a local name until more evidence is secured.

At **Coal Exposure No. 769 on Map II,** in Mercer County along the Bluefield-Bramwell road one mile southeast of Simmons, the blossom of this coal is visible at elevation 2735′ B., dipping steeply northwestward in the highly tilted beds west of the Abbs Valley Anticline.

At **Coal Exposure No. 770 on Map II,** in Tazewell County, in the cut of the Norfolk & Western Railway on the south side of Bluestone River one-half mile northwest of the new station at Graham (now Bluefield, Virginia), this being the type locality of the Graham Coal, it is well displayed as published in the Graham Section, page 191, being 1′ 9″ thick, soft, and slaty.

At the **William Blankenship Prospect (No. 771 on Map II),** located in the same county on the north side of Bluestone River opposite No. 770, the coal was once opened for local use at elevation 2385′ B., but the place has fallen completely

[17]Ibid., pp. 224-225.

shut. According to residents of the neighborhood the coal was four feet thick, but it is doubtful if such a thickness could be more than a mere pocket since it was not observed in such quantity elsewhere in the region and it is probable that the steep northwestward dip of 30 degrees may have caused confusion in the estimated size of the bed.

At the **Pat Rohr Exposure (No. 772 on Map II)**, in Mercer County, on the south slope of Stony Ridge 0.5 mile northwest of the Bluefield, West Virginia, station, the blossom of the coal is exposed at elevation 2790′ B., but no reliable estimate of its thickness could be made in these crushed and overturned strata.

At **Coal Exposure No. 773 on Map II,** in Mercer County along the Bluefield-Princeton road 0.2 mile southwest of Stony Gap, the coal shows a thickness of 0′ 6″, at elevation 2500′ B., as recorded in the Stony Gap Section, page 197.

In Summers County this coal appears to be represented by a five-foot bed of sandy shale containing plant fossils and iron pyrites in the road along the east side of Hungard Creek 1.7 miles north of Pence Springs at elevation 1800′ B., as recorded in the Pence Springs Section, page 253. Unfortunately no collection of the plants at this locality was made. In Monroe County its horizon outcrops along the northwestern edge but the coal was not recognized.

It does not appear probable that any coal of appreciable value can be recovered from the Graham horizon in the three counties.

LOWER GRAHAM SHALE.

The **Lower Graham Shale** (new) is a thick deposit of red, variegated, and sandy shale containing occasional lenses of sandstone and coming between the Graham Coal and Bertha Sandstone, its thickness usually varying from 50 to 75 feet. It is named from association with other members of the Graham stage but at the type locality of these formations as above described in Tazewell County there is only 15 feet of gray, fire clay shale at the Lower Graham horizon, as recorded

in the Graham Section, page 191. In the Stony Gap Section of Mercer County, page 198, there is a bed of 4½ feet of dark shale at its horizon.

In Monroe County it is recorded in the sections of Chapter V for Red Sulphur Springs, page 219, being 40 feet thick, red, green, and variegated, and in that for Wikel, page 220, where it is 45 feet thick and greenish-gray. In Summers County it is noted in the sections for Indian Mills and Pence Springs, pages 265 and 253, respectively. Its horizon may be studied at numerous other points in the three counties but, so far as observed, it contains no fossils and is of little economic importance since it usually contains sandy beds that would preclude its use as brick material.

BERTHA SANDSTONE.

The **Bertha Sandstone** (new) is the first regular bed of this character below the Graham Coal, its interval below the Stony Gap Sandstone being more than 350 feet in the region of maximum intervals. As a rule it is greenish-gray, shaly, and varying in thickness from 30 to 50 feet but in some localities it becomes massive and gray. Its type locality is in Summers County along the mountain road which ascends from Bertha toward Low Gap School, being there shaly and 45 feet thick, at elevation 1555′ B., as recorded in the Bertha Section, page 261.

Elsewhere in Summers County it is exhibited in the sections of Chapter V for Alderson, Bertha, Glenray, Indian Mills, Marie, Pence Springs, Talcott, and Warford. On the west side of New River at Bull Falls it appears to be this sandstone making a cliff 50 feet thick about 130 feet above the river, and on the north side of Indian Creek 0.5 mile northeast of Junta it makes a prominent cliff in the brow of the mountain at elevation 1690′ B., being greenish-brown, hard, massive, and 30 feet thick. Beneath this ledge there is green shale with marine fossil fragments, evidently the Upper Bertha Shale. On the head of Bradshaw Creek it is visible in the Forest Hill-Indian Mills road 0.6 mile southwest of the former

locality, being 20 feet thick, massive, and hard, of which a cliff is made by a five-foot portion, the top of the rock being at elevation 1825′ B. In the region south of the Big Bend of Greenbrier River it makes a shaly cliff on Spruce Run 0.4 mile above its mouth, there being 20 feet visible with the top at elevation 1525′ B.

In the edge of Tazewell County, Virginia, it is visible in the cut of the Norfolk & Western Railway on the south side of Bluestone River one-half mile northwest of the new station at Graham (now Bluefield, Virginia), being 5 feet thick and shaly, as recorded in the Graham Section, page 191. Here it contains plant fossils, and **Fossil Lot 124 on Map II** was collected by Dr. David White, Mr. Price, and the writer, some of the material being from the Upper Graham Shale which is there 16 feet above the top of the sandstone. Dr. White's discussion of these plants will be found in Chapter XVII. In Mercer County it is exhibited in the Stony Gap Section, page 198, being 20 feet thick, white, and hard.

In Monroe County it is noted in the Red Sulphur Springs and Wikel Sections, pages 219 and 220, respectively, being shaly at both localities, but in the vicinity of Mt. Hope School on the eastern side of the southern end of Wolf Creek Mountain it makes several massive exposures along the public road.

So far as known this stone has not been quarried but at various points where it becomes massive it would make good building stone for structures where an artistic finish is not required.

UPPER BERTHA SHALE.

The **Upper Bertha Shale** (new), coming just under the Bertha Sandstone, is usually a sandy but sometimes red and variegated deposit, varying in thickness from 45 to 75 feet and having occasional plant or marine fossils. It is named from association with the Bertha Sandstone, its horizon being concealed at the type locality of the latter near Bertha, Summers County. Elsewhere in this county it is exhibited in the sections of Chapter V for Alderson, Glenray, Indian Mills, and

Warford and on the mountain north of Indian Creek 0.5 mile northeast of Junta some of it is visible beneath the Bertha Sandstone ledge at elevation 1690′ B., and there contains fragments of marine fossils.

In Mercer County it is recorded in the Stony Gap Section, page 198, being 45 feet thick, of which the lower five-foot portion is dark and fissile. In Monroe County it is noted in the sections of Chapter V for Red Sulphur Springs and Wikel. No collections of its plant and marine fossils were made at any locality.

BERTHA LIMESTONE.

The **Bertha Limestone** (new), belonging just under the Upper Bertha Shale and 30 to 75 feet below the Bertha Sandstone, is a yellow, impure, and siliceous bed, varying in thickness from 2 to 15 feet and often carrying marine fossils, both brachiopods (including **Orthotetes)** and pelecypods. It is named from association with the Bertha Sandstone and Upper Bertha Shale but at the type locality of the former, near Bertha, Summers County, its horizon is concealed. In the same county, however, it is exposed in the sections of Chapter V for Indian Mills, Marie, and Warford, there being pelecypods at Indian Mills while the Warford exposure contains bryozoa in addition to other classes. On the road which passes up Bradshaw Creek from Indian Mills to Forest Hill it is visible 0.7 mile southwest of the latter point at elevation 1780′ B., with a thickness of two feet.

In the edge of Tazewell County, Virginia, it is recorded in the Graham Section, page 191, being two feet thick and shaly; and in the portion of Giles which extends northward between Mercer and Monroe it is noted in the Lurich Section, page 204, as gray, hard, and 5 feet thick.

In Monroe County it is well exposed along the mountain road west of Fitz Run and one mile south of Red Sulphur Springs at elevation 1745′ B., with a thickness of 15 feet and with marine fossils, as recorded in the Red Sulphur Springs Section, page 219. Here Dr. Girty and the writer collected

Fossil Lot 162 on Map IV, there being brachiopods (especially **Orthotetes),** pelecypods, and crinoids, as listed in more detail by Dr. Girty in Chapter XVIII. On the road west of Indian Creek and 0.4 mile northwest of Red Sulphur Springs it is again visible at elevation 1620′ B., being 10 feet thick and shaly and containing marine fossils among which there are **Orthotetes** and other brachiopods.

This limestone is of much scientific interest because of its fauna but it is too shaly and impure to be of much economic use.

LOWER BERTHA SHALE.

The **Lower Bertha Shale** (new) is a greenish-yellow, but occasionally red and variegated or sandy, deposit, varying in thickness from 50 to 90 feet and coming just below the Bertha Limestone and just over the persistent Bradshaw Sandstone, there being occasional streaks of limestone and frequent marine fossils, among which pelecypods were noted. It is named from association with the other members of the Bertha stage but at the type locality of the Bertha Sandstone in Summers County its horizon is concealed. In the same county, however, it is recorded in the sections of Chapter V for Alderson, Indian Mills, Marie, Pence Springs, and Warford. In Mercer County and in the edge of Tazewell it is exhibited in the Stony Gap and Graham Sections and in Monroe County by those for Red Sulphur Springs and Wikel.

Its marine fossils, so far as observed, are pelecypods, these being sometimes found in the shale and sometimes in the lenticular limestones, but no collection was made at any locality. Abundant exposures of this rather interesting shale may be observed in all of the three counties.

BRADSHAW SANDSTONE.

The **Bradshaw Sandstone** (new) is a greenish-gray, shaly or massive, medium-grained ledge, varying in thickness from 30 to 50 feet and having its base about 600 feet below the Stony Gap Sandstone in the region of maximum intervals

but only about 450 feet below that horizon in southeastern Summers County. Its type locality is in Summers County in the vicinity of Indian Mills and along Bradshaw Creek, there being a cliff on the road which ascends the mountain immediately north of Indian Mills and the mouth of Bradshaw Creek. Here, as recorded in the Indian Mills Section, page 265, it is greenish-brown, massive at the top but shaly at the base, 30 feet thick, and makes a prominent cliff at elevation 1615′ B. Along the same creek this ledge is visible just west of Bradshaw School at elevation 1600′ B., as well as at other points intermediate between the school and the type locality, and at many other points in the three counties it makes frequent cliffs.

Elsewhere in Summers County its position and thickness are exhibited in the sections of Chapter V for Alderson, Glenray, Marie, Pence Springs, and Warford. On New River it rises above drainage between Bertha and Warford and appears to be the rock which makes Bull Falls, the exposure on the west side of the river, as estimated from the east side, being as follows:

		Feet.
1.	**Sandstone, Bertha,** shaly, makes cliff	50
2.	Concealed (estimated)	100
3.	Sandstone, shaly, to river	30′ **Bradshaw Sandstone**
4.	Sandstone, in Bull Falls	10 (1395′ B.) 40

A little farther up the valley the sandstone makes wide shoals in the vicinity of Warford but shortly above Buffalo Creek it emerges completely and makes prominent ledges in the region below Junta. On Greenbrier River in the region south of the Big Bend it becomes a huge cliff, being visible on the south side of the river just east of the mouth of Spruce Run where it makes a shaly ledge 50 feet thick at elevation 1490′ B., and being exposed at two or three points along the road between Kissinger Run and Little Stony Creek, while in the narrow ridge between Little Stony and Stony Creeks it makes a bold ledge 60 feet thick, as will be later detailed in Local Measurement at **Fossil Lot 187 on Map VI.** East of Stony Creek it rises rapidly and forms the low ridge just south of Bargers Springs.

In the edge of Tazewell County, Virginia, the Bradshaw Sandstone is noted in the section for Graham, page 192, being 10 feet thick and shaly, and in Mercer County it is exhibited in the Stony Gap Section, page 198, where it is 15 feet thick, green, and ripple-marked. On the west side of New River 1.9 miles south of Mercers Salt Works it makes a 10-foot ledge, the top of which is at elevation 1505′ B., its nature being coarse and hard. At other points in Mercer County it may frequently be observed at its proper horizon.

In Monroe County it is recorded in the Red Sulphur Springs and Wikel Sections, pages 219 and 220, respectively, being shaly at the former but massive and coarse at the latter locality. On the north side of Indian Creek 0.6 mile northeast of Raines Corner it makes a 20-foot cliff at elevation 1860′ B., being greenish-gray, massive, and coarse, with quartz crystals on the cleavage-planes. On the west side of Rock Camp Creek 0.3 mile south of Raines Corner the following exposure is visible:

		Feet.
1.	Sandstone, flaggy and concealed	40
2.	**Sandstone, Bradshaw**, gray, hard, coarse, massive, makes cliffs (1755′ B.)	20
3.	Concealed and red shale, **Bradshaw Shale**	30
4.	**Sandstone, Indian Mills**, shaly	15
5.	**Shale, Indian Mills**, sandy, with streaks of limestone to creek; long pelecypods and brachiopods	15

On the east side of Rock Camp 0.6 mile north of Rock Camp village it makes a visible 10-foot ledge at elevation 1805′ B., and on the same side of the creek 0.3 mile northwest of the village its top is exposed in the old alignment of the county road at elevation 1785′ B. On the north side of Indian Creek 2.8 miles north of Red Sulphur Springs the following exposure is visible:

		Feet.
1.	**Sandstone, Bradshaw**, shaly cliff (1635′ B.)	25
2.	Concealed, with red shale, **Bradshaw Shale**	25
3.	**Sandstone, Indian Mills**, massive, coarse cliff	25

Twin cliffs of the above character are often made by the Bradshaw and Indian Mills Sandstones, separated by 25 to 50 feet of the soft Bradshaw Shale.

So far as known the Bradshaw Sandstone has not been quarried at any point but there are numerous localities where it is sufficiently durable to make good building stone and it would not be difficult to quarry and work, while at the same time the color and texture are very good.

BRADSHAW LIMESTONE.

The **Bradshaw Limestone** (new) is a shaly, siliceous, and lenticular calcareous bed, coming just below the Bradshaw Sandstone and being usually less than three feet thick, but containing marine fossils, including brachiopods, pelecypods, and gastropods. It is named from association with the Bradshaw Sandstone although it was not noted at the type locality of the latter, but is well and conveniently exposed at the following observation:

Local Measurement at Fossil Lot 187.

Talcott District, Summers County; in bluff south of Greenbrier River, just west of Stony Creek and 0.3 mile southwest of Bargers Springs; dip, northwest; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (120′)		
1. **Sandstone, Bradshaw,** grayish-white, massive, very hard, makes great cliffs (1515′ B.)	60	60
2. **Limestone, Bradshaw,** shaly, contains marine fossils, brachiopods, pelecypods, and gastropods (see Lot 187)	3	63
3. **Shale, Bradshaw,** red and sandy, partly concealed.	42	105
4. **Sandstone, Indian Mills,** shaly	10	115
5. Shale, sandy	5	120

Fossil Lot 187 on Map VI was collected at the above locality by Dr. Girty and the writer, the detailed report on which by the former will be found in Chapter XVIII.

In the road along the east side of New River just northwest of Junta this limestone is visible just under the shaly ledge of the Bradshaw Sandstone at elevation 1505′ B., being four feet thick and siliceous.

It is not apparent that this limestone has any economic use, since it is quite impure, but the included fauna makes it of scientific interest.

BRADSHAW SHALE.

The **Bradshaw Shale** (new) is usually a red and variegated, but sometimes green and sandy deposit, coming just under the Bradshaw Limestone or when that formation is absent, just under the Bradshaw Sandstone, and having an average thickness of 30 to 40 feet but frequently expanding to greater proportions. It contains occasional marine fossils, among which pelecypods have been noted; and also plant fossils. Its type locality is in Summers County on the mountain road immediately north of Indian Mills, where, as exhibited in the Indian Mills Section, page 266, it is a plain red shale 55 feet thick and coming just below the cliff of the Bradshaw Sandstone.

In other parts of Summers County the shale is noted in the sections of Chapter V for Alderson, Glenray, Marie, and Pence Springs and it was recognized at many local exposures between the Bradshaw and Indian Mills Sandstone cliffs.

In Tazewell County, Virginia, it occurs along Bluestone River as recorded in the Graham Section, page 192, being 75 feet thick, but at the Stony Gap Section in Mercer County, page 198, the shale is only 17 feet thick and is separated into two benches by a lenticular coal.

In Monroe County it is recorded in the Red Sulphur Springs and Wikel Sections, pages 219 and 220, respectively, being more than 100 feet at each of these localities. In the western edge of the county it contains abundant pelecypods at an exposure in the road near the southern base of Wind Creek Mountain 0.8 mile east of Crossroads School and 1.3 miles northeast of Ballengee, at elevation 1930′ B., being there green and sandy. Farther south the following interesting observation was obtained:

Local Measurement at Fossil Lot 230.

Springfield District, Monroe County; in road on east side of Rock Camp Creek 0.6 mile northwest of Rock Camp; gentle northwest dip; arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (21′)		
1. **Shale, Bradshaw,** dark, sandy, with marine fossils (pelecypods) at base, and with plant fossils in lower portion	15	15
2. Shale, black, bituminous, **Red Sulphur Coal** horizon, (1800′ B.)	1	16
3. **Shale, Bradshaw** (continued), sandy, with plant fossils	3	19
4. Sandstone, shaly	2	21
Collection of plant fossils from Nos. 1 and 3 (see **Lot 230**).		

Fossil Lot 230 on Map IV was collected at the above locality by Dr. David White, Mr. Price, and the writer, the discussion of which by Dr. White will be found in Chapter XVII. At this point the overlying Bradshaw Sandstone which may be noted slightly northward had weathered away leaving only the shale exposed.

No collection of marine fossils was made in the Bradshaw Shale at any locality, although it frequently contains many pelecypods which would be of interest. These are usually to be found in places where the shale is green and slightly calcareous or even sandy but when it is predominantly red they appear to be mostly absent.

In regions where this shale is red and argillaceous and free from included sandy or calcareous matter it should make a very good grade of building brick. There are numerous such exposures in all three counties.

The **Red Sulphur Coal** (new) is a lenticular bed that occurs at a few points within the body of the Bradshaw Shale, being usually one foot or less in thickness when present at all. In Mercer County it is visible at **Coal Exposure No. 774 on Map II,** along the Bluefield-Princeton road 0.3 mile southwest of Stony Gap at elevation 2490′ B., but is only a blossom, as recorded in the Stony Gap Section, page 198. At **Coal Exposure No. 775 on Map IV,** in Monroe County, in the road along the east side of Fitz Run 0.3 mile south of Red Sulphur Springs it is well exposed at elevation 1590′ B., consisting of two benches of coaly slate separated by a thin streak of limestone, as detailed in the Red Sulphur Springs Section, page 219, this being the type locality.

In Summers County it is visible at **Coal Exposure No. 776 on Map VI** on the south side of Griffith Creek 0.3 mile northwest of Santifee at elevation 1710′ B., but is little more than a blossom, as indicated in the Glenray Section, page 255. In the same county the following prospect appears to represent it:

John Redman Prospect—No. 777 on Map VI.

On the north side of Indian Creek 0.6 mile southeast of Indian Mills; **Red Sulphur Coal**; elevation, 1530′ B.

		Feet.
1.	Sandstone, shaly	10
2.	Shale, green and red	5
3.	Sandstone, shaly	5
4.	Shale, black, **coaly**, with iron pyrites, **Red Sulphur Coal** horizon, streak	..
5.	Concealed, with shale and sandstone, to creek	20
6.	**Sandstone, Indian Mills**, in creek bed	..

The above prospect is known locally as the **"Redman Gold Mine"**, having been started in the evident belief that the yellow crystals of iron pyrites in No. 4 were those of the more precious metal, which proved to be wrong.

INDIAN MILLS SANDSTONE.

The **Indian Mills Sandstone** (new), coming just under the Bradshaw Shale and having its base about 700 feet below the Stony Gap Sandstone in the region of maximum intervals and about 575 feet below it along Indian Creek, is usually a greenish-gray, fine-grained ledge, partly massive and partly shaly, and varying in thickness from 30 to 60 feet. Its type locality is in Summers County on the north side of Indian Creek just west of Indian Mills where, as exhibited in the Indian Mills Section, page 266, it consists of green, fine-grained, massive beds, separated by some streaks of shale, the entire thickness being 75 feet and the elevation of its base 1485′ B. Elsewhere in the county it is recorded in the sections of Chapter V for Alderson, Pence Springs, and Warford. From Indian Mills southwestward along Indian Creek this sandstone makes a heavy ledge of overhanging cliffs along

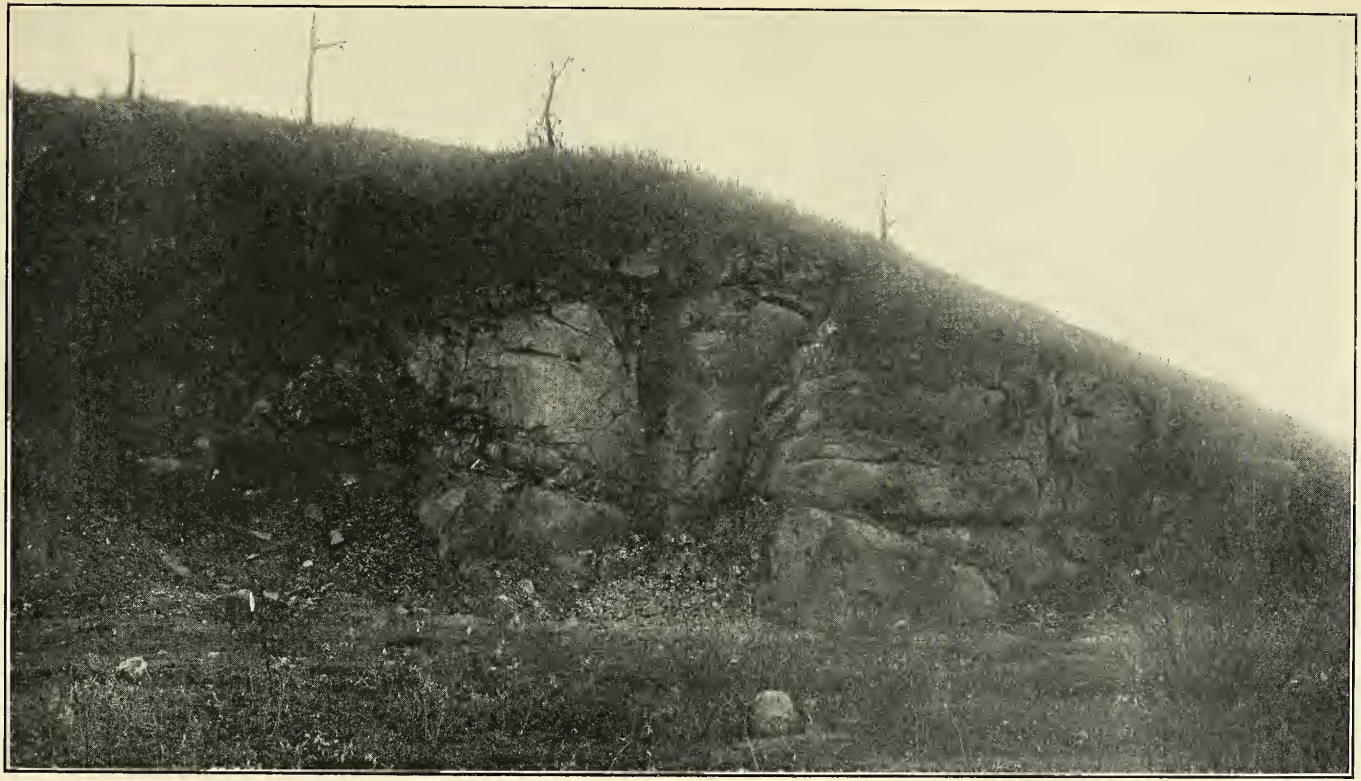

PLATE XXI.—Portion of Alderson Limestone in quarry of Lewis McNeer on south side of Indian Creek near Salt Sulphur Springs, Monroe County. (Photo. by Palmer & Fowler).

the public road and slightly above the creek, but at the mouth of the creek just south of Junta it has partly submerged, there being 20 feet of it visible above water-level. Farther northeast it is visible at the Summers-Monroe line just south of Wind Creek Mountain and 0.7 mile east of Crossroads School at elevation 1910′ B., being 15 feet thick, massive, and coarse.

In the edge of Tazewell County, Virginia, it is recorded in the Graham Section, page 192, as 40 feet thick and mostly massive, and in the Stony Gap Section of Mercer County, page 198, it is 100 feet thick but much weathered out so that its character is not easily recognized. In the edge of Giles County, Virginia, it is noted as 20 feet thick, gray, coarse, and massive in the Glenlyn Section, page 203. In Monroe County the Red Sulphur Springs and Wikel Sections both record it. On Flint Hollow of Kelly Creek just northeast of Creamery it makes a 30-foot cliff in the hill above **Coal Exposure No. 790 on Map IV,** as will be later detailed. On Hands Creek 0.3 mile southwest of Assurance it is 30 feet thick at elevation 1810′ B. Under the description of the Bradshaw Sandstone its presence at local measurements on Indian Creek 2.8 miles north of Red Sulphur Springs and on Rock Camp Creek 0.3 mile south of Raines Corner has already been detailed. On the west side of the former creek it makes a 25-foot cliff along the old county road 0.2 mile north of Raines Corner at elevation 1700′ B., and on the latter it is visible in the churchyard at Rock Camp village, being gray, coarse, massive, and hard at elevation 1840′ B. From this point it rises rapidly southeastward and makes a reef in the ridge 0.3 mile southeast of the village at elevation 2055′ B., the dip being northwestward at an angle of 30 degrees.

So far as known the Indian Mills Sandstone has not been quarried, but at various localities in the three counties it is sufficiently massive and durable that it could be used for building purposes if so desired, and its texture in general is such that its architectural effect would not be displeasing.

INDIAN MILLS SHALE.

The **Indian Mills Shale** (new) is a green or red and varie-

gated deposit belonging just below the Indian Mills Sandstone and usually varying in thickness from 60 to 70 feet and having frequent marine fossils, mostly pelecypods, among which **Sphenotus** and **Myalina** are prominent, and also occasional plant fossils. Its type locality is in Summers County on the north side of Indian Creek just west of Indian Mills, where it occurs just below the ledge of the Indian Mills Sandstone and is green and sandy, and contains numerous marine fossils, largely, if not entirely, pelecypods, **Sphenotus** and **Myalina** being most abundant. The base of the Indian Mills Sandstone is only 15 feet above the creek at this point, however, and of this interval only the upper five-foot portion is exposed, so that the full thickness of the shale is not revealed, as exhibited in the Indian Mills Section, page 266. Here the writer collected **Fossil Lot 165 on Map VI,** the detailed list of which as studied by Dr. Girty, appears in Chapter XVIII. In the Pence Springs Section, page 253, the shale is 20 feet thick, being partly red and variegated but containing two benches of limestone and marine fossils among which pelecypods were noted.

On the north side of Indian Creek 1.1 miles northwest of Red Sulphur Springs the following local measurement was obtained:

		Feet.
1.	**Sandstone, Indian Mills,** shaly (1525′ B.)	10
2.	**Shale, Indian Mills,** green, with nodules of iron ore and with marine fossils; contains pelecypods, there being a striated shell which may be **Myalina**	5
3.	Concealed and sandstone to creek	10

In Mercer County the horizon of the Indian Mills Shale is entirely concealed at the Stony Gap Section; and at the Glenlyn Section, in Giles County, Virginia, the shales beneath the Indian Mills Sandstone are also too poorly exposed for differentiation; and at the Lurich Section, in the same county, they are again concealed.

In Monroe County the shale is recorded in the Red Sulphur Springs Section, page 219, being sandy and containing calcareous nodules, but being only seven feet thick. In the Wikel Section, pages 220-1, it is 40 feet thick and contains

both plant and marine fossils, the zone of the former being one-half foot thick and occurring 20 feet below the top of the shale and between two beds of marine fossils. **Fossil Lot 159 on Map IV** was collected from the plants at this point by the writer, and was studied by Dr. David White as described in Chapter XVII. **Fossil Lot 159A on Map IV** was also collected by the writer from the zones immediately below and above the plant fossils there being pelecypods among which **Sphenotus** was noted as described by Dr. Girty in Chapter XVIII.

On the north side of Indian Creek 0.7 mile northeast of Raines Corner the shale is visible in the edge of the old county road, being reddish-brown and sandy with streaks of shaly sandstone, with a thickness of 20 feet, at elevation 1720′ B. Here it contains numerous small, smooth pelecypods. Just north of the ford which crosses Indian Creek at the mouth of Rock Camp Creek and just south of Raines Corner there is a dark limestone, two feet thick, exposed at elevation 1700′ B., followed below by three feet of sandy shale, as observed by Mr. Price and the writer, these being at the Indian Mills Shale horizon. In the limestone the pygidium of a trilobite was found. On the west side of Rock Camp Creek 0.3 mile south of Raines Corner the shale is again exposed just above the creek, there being 15 feet of it visible with marine fossils, both pelecypods and brachiopods, as exhibited in the local measurement published under the description of the **Bradshaw Sandstone,** page 396. On the east side of Rock Camp Creek 0.7 mile southeast of Raines Corner it is exposed at elevation 1735′ B., being sandy with streaks of limestone and containing long pelecypods and another shell which may be **Myalina.** On Hands Creek 0.3 mile northwest of Assurance it is red and green and contains long pelecypods in addition to the same striated shell which occurs in **Lot 159A** and is evidently **Myalina,** there being 10 feet of the shale at elevation 1865′ B. On Flint Hollow of Kelly Creek, just northeast of Creamery, the shale is visible again, being exhibited in the description of **Coal Prospect No. 790 on Map IV,** published on a later page.

Owing to the frequent content of both siliceous and cal-

careous matter the Indian Mills Shale would not generally be suitable for brick making or other ceramic uses but it is of much interest because of its plant and marine fossils.

RAINES CORNER LIMESTONE.

The **Raines Corner Limestone** (new) occurring just under the Indian Mills Shale, with an interval beneath the Stony Gap Sandstone that varies from 425 to 775 feet, depending on the locality, and belonging about 475 feet above the base of the Bluefield Group in the region of maximum intervals, is one of the most easily recognized members of the entire group. It is almost invariably dark and hard, weathering gray on long exposure, varying in thickness from five to ten feet, and containing numerous marine fossils, among which brachiopods, pelecypods, and gastropods were noted. Among the latter **Bellerophon** is nearly always present in considerable abundance, there being no other formation in the Bluefield Group where it is nearly so common, so that it is a favorable clue in the identification of the bed, although it may not be considered as entirely diagnostic. At many points, also, the limestone contains fucoidal markings on its weathered surface which are of service in its identification. The member is widely persistent, being visible at nearly all localities where its horizon occurs above drainage in the three counties.

Its type locality is in Monroe County in the bed of Indian Creek 0.5 mile northwest of Raines Corner, as exhibited in the Wikel Section, page 221. Here it is gray on its weathered surface but dark on fresh fracture, shaly, fucoidal, and contains marine fossils among which brachiopods, pelecypods, and the gastropod **Bellerophon** were noted, there being five feet of it visible above drainage. **Fossil Lot 158 on Map IV** was collected by the writer, the detailed report of which by Dr. Girty will be found in Chapter XVIII.

In the same county it is recorded in the Red Sulphur Springs Section, page 219, there being 10 feet of it visible on Fitz Run just above the level of Indian Creek at Red Sulphur Springs village. Here it is dark-gray, stylolitic at the base,

and contains marine fossils in the upper portion, among which brachiopods, gastropods (**Bellerophon**), and bryozoa were noted. **Fossil Lot 248 on Map IV** was collected by Mr. Price and the writer, the detailed list of which by Dr. Girty will be found in Chapter XVIII.

On Humphreys Run of Indian Creek 0.2 mile above its mouth and 1.2 miles northeast of Raines Corner, the limestone is visible at elevation 1730′ B., being dark and shaly, 15 feet thick, and containing marine fossils among which brachiopods were noted. One-half mile up this same run it is again visible in an anticlinal flexure at elevation 1780′ B., and at **Coal Prospect No. 787 on Map IV,** 0.7 mile up the same run, it is gray, shaly, and five feet thick, as later exhibited in connection with this prospect. On the west side of Indian Creek 1.4 miles northeast of Raines Corner it is visible at **Coal Exposure No. 788 on Map IV,** being 10 feet thick and containing **Bellerophon** as described under this prospect on a later page. On the same side of Indian Creek 1.6 miles northeast of Raines Corner it is again visible at **Coal Exposure No. 789 on Map IV** but is partly concealed as exhibited on a later page in the description of this outcrop. On the ridge 0.5 mile southwest of Rock Camp village it is visible at elevation 2050′ B., being five feet thick and carrying the gastropod **Bellerophon,** and dipping northwestward at an angle of 40 degrees, as observed by Mr. Price and the writer.

On Dry Creek just east of Flatwoods Church and 1.8 miles southeast of Rock Camp village it is visible in the road at elevation 2090′ B., being dark but split into three benches, and containing both fucoids and the gastropod **Bellerophon** as observed by Mr. Price and the writer. On Hands Creek 0.7 mile northeast of Assurance it occurs as calcareous streaks in shale just above the Raines Corner Coal at **Coal Prospect No. 784 on Map IV,** as later described. At the summit between Hands Creek and Cooks Run 0.7 mile north of Assurance it is five feet thick, coming 20 feet above the Raines Corner Coal, as detailed in description of **Coal Prospect No. 783 on Map IV** on a later page. Immediately southward along the same road and 0.4 mile north of Assurance it is five feet thick at eleva-

tion 1875′ B., being hard and grayish-blue and containing marine fossils among which pelecypods and brachiopods (including **Orthotetes**) were noted. At the road fork on Blue Lick Creek one mile west of Assurance it is exposed at elevation 1730 B., its weathered surface having a gray color. On the east side of Hands Creek 0.7 mile south of Indian Creek School and 2.3 miles west of Greenville it is visible at elevation 1730′ B., its weathered surface having a gray color. On **Map IV** and containing **Bellerophon**, as detailed under this prospect on a later page. On the north side of Indian Creek at Indian Creek School 2.5 miles west of Greenville it is five feet thick at **Coal Exposure No. 781 on Map IV**, as described on a later page, and in the sharp point of the hill 0.1 mile northeast of the school it is seven feet thick at elevation 1650′ B., and contains numerous **Bellerophon**, there being a northwestward dip of 3 degrees. In the road along Indian Creek 2.8 miles west of Greenville and 0.1 mile east of Symms Branch it is gray and hard at elevation 1575′ B., and contains numerous marine fossils among which crinoids, gastropods **(Bellerophon)** and brachiopods (including **Orthotetes**) were noted, there being a visible thickness of 15 feet. On the same creek 0.6 mile west of Symms Branch it is again exposed at elevation 1565′ B., with a thickness of five feet, being hard, gray, impure, and slightly ferruginous and containing both gastropods and crinoids.

Farther north it is well exposed in the hill road west of Wolf Creek and 1.9 miles northeast of Wayside at elevation 2040′ B., being 20 feet thick, and black, but weathering yellow, shaly, and dipping westward at the rate of 15 degrees. Here the writer collected **Fossil Lot 167 on Map IV**, there being crinoids, gastropods **(Bellerophon)**, pelecypods, brachiopods, and bryozoa, as detailed by Dr. Girty in Chapter XVIII. On Flint Hollow of Kelly Creek just northeast of Creamery it is five feet thick, dark, and shaly, and contains brachiopods as detailed in the description of **Coal Exposure No. 790 on Map IV** on a later page; and on the same hollow 0.8 mile northeast of Creamery it is five feet thick at elevation 1795′ B.

In Mercer County it is exposed in the southern slope of Stony Ridge 0.5 mile west of Ada, partly in the public road and partly in the field above it, as exhibited in the local measurement at **Fossil Lots 43A, 251, and 252 on Map II,** published on a later page under the description of the Ada Shale. Here it is shaly and five feet thick and contains marine fossils among which there are brachiopods (including **Orthotetes** and **Diaphragmus)** and gastropods. At this point **Fossil Lot 43A** was collected by Dr. Prouty and the writer in the early stage of field work in this county and included species from both the Raines Corner Limestone and Ada Shale, and also from an intermediate bed of limestone. This collection was forwarded by Dr. Prouty to Dr. E. M. Kindle who was apparently unable to give it attention. At a later visit the writer collected **Fossil Lot 252** from the Raines Corner Limestone, the fauna being as above outlined but more particularly described by Dr. Girty in Chapter XVIII.

On the same slope of Stony Ridge at **Coal Prospect No. 778 on Map II** one-half mile northeast of Ada it is visible just north of the coal prospect and contains both gastropods and brachiopods as detailed in the description of this prospect on a later page. In the edge of Giles County, Virginia, it is well exposed in the cut of the Norfolk & Western Railway on the east side of East River 0.1 mile south of Glenlyn, being 25 feet thick, dark, and containing gastropods, brachiopods, and other marine fossils as exhibited in the description of **Coal Exposure No. 779 on Map II** on a later page.

In Summers County the Raines Corner Limestone is recorded in the Alderson Section, page 258, its full thickness not being exposed, and in the Glenray Section, page 255, it is shaly, five feet thick, and contains marine fossils among which gastropods **(Bellerophon)** and brachiopods were noted, At this exposure which is on the south side of Griffith Creek at the base of the road starting up Dempsey Mountain 1.5 miles west of Glenray, at elevation 1705′ B., Dr. Girty and the writer collected **Fossil Lot 220 on Map VI,** a more detailed account of which by the former will be found in Chapter XVIII.

At **Fossil lot 222 on Map VI,** located near the base of the hill road from Pence Springs to Clayton 0.3 mile north of the former at elevation 1555′ B., Dr. Girty and the writer made a collection as exhibited in the Pence Springs Section, page 254. Here the bed consists of green, calcareous shale with streaks of hard limestone in which marine fossils occur, including brachiopods and the gastropod **Bellerophon,** as more fully detailed by Dr. Girty in Chapter XVIII. On the west side of Greenbrier River 0.8 mile northwest of Lowell the following observation was obtained:

			Feet.
1.	**Sandstone, Indian Mills,** massive cliff		25
2.	Concealed ..... 25′		
3.	Sandstone, shaly..... 10		
4.	Shales, sandy, red and variegated 15	**Indian Mills Shale...**	62
5.	Limestone, shaly..... 2		
6.	Shale, calcareous..... 10		
7.	**Limestone, Raines Corner,** hard, with marine fossils, gastropods, etc. (1525′ B.)		5
8.	**Shale, Raines Corner,** calcareous		15
9.	Concealed		20
10.	**Sandstone, Droop,** in Greenbrier River		..

In the road which passes from Talcott to Bargers Springs the limestone is visible in the flats 0.5 mile south of Talcott, at elevation 1600′ B., being dark, hard, and containing marine fossils, among which gastropods and brachiopods, together with markings apparently made by fucoids, were noted by Mr. Price and the writer.

The following local measurement was obtained along the same road:

Local Measurement at Fossil Lot 186.

Talcott District, Summers County; in road from Talcott to Bargers Springs, 1.5 miles south of Talcott; dip, northwest; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (20′)			
1.	Shale, green	..	....
2.	**Limestone, Raines Corner,** blue, weathering yellow (1725′ B.); contains marine fossils, chiefly brachiopods and gastropods (especially **Bellerophon**) (see **Lot 186**)	5	5
3.	**Shale, Raines Corner,** green	15	20
4.	**Sandstone, Droop,** massive, near drainage	..	....

At the above locality **Fossil Lot 186 on Map VI** was collected by the writer, the fauna of which, as studied by Dr. Girty, will be more completely detailed in Chapter XVIII.

Just northeast of Bargers Springs the limestone is visible at elevation 1780′ B., at a small cavern through which the drainage flows, being dark, five feet thick, and containing marine fossils including **Bellerophon,** and also having fucoids, as observed by Mr. Price and the writer.

It is not apparent that this limestone will prove to be of much economic use since it is usually impure, but its value as a correlation plane is especially good in all three counties; and in the Greenbrier Valley of West Virginia, it may also be followed into other counties. Outside of the State it has been traced as far southward as Big Stone Gap, Virginia.

RAINES CORNER SHALE.

The **Raines Corner Shale** (new) is a green or grayish, sandy deposit coming between the Raines Corner Limestone and Raines Corner Coal, and usually varying from 5 to 10 feet in thickness but occasionally being slightly heavier, there being plant or marine fossils at some localities. Its type locality is in Monroe County on the west side of Indian Creek along the State road about 1½ miles northeast of Raines Corner, as exhibited at **Coal Exposures Nos. 788 and 789 on Map IV** on later pages under the discussion of the Raines Corner Coal. In the same county it is recorded with the coal at **Coal Exposure No. 787 on Map IV** on Humphreys Run of Indian Creek; also in the Wikel Section, page 221; also on a branch of Hands Creek northwest of Assurance at **Coal Exposure No. 783 on Map IV**; also on Indian Creek just west of Indian Creek School at **Coal Exposure No. 781 on Map IV**; and also on Flint Hollow of Kelly Creek just northeast of Creamery at **Coal Exposure No. 790 on Map IV.**

In Mercer County the horizon of this shale is concealed in the Stony Gap Section, and in the gaps of Stony Ridge farther east its bed is much crushed and distorted, but in the edge of Giles County it is visible in the Norfolk & Western

Railway cut on the east side of East River just south of Glenlyn at **Coal Exposure No. 779 on Map II.**

In Summers County it is poorly exposed at the Alderson, Glenray, and Pence Springs Sections, all of which cross its horizon, but in this region there should be points where it could be studied if so desired.

RAINES CORNER COAL.

The **Raines Corner Coal** (new) is a persistent, carbonaceous horizon occurring just under the Raines Corner Shale and from 5 to 20 feet below the Raines Corner Limestone, its interval below the Stony Gap Sandstone in the region of maximum thicknesses being nearly 800 feet but decreasing in eastern Summers County to little more than 500 feet. The coal is usually slaty and impure, varying in thickness from one to two feet, there being several points where attempts have been made to use it for local fuel. The following prospects and exposures were observed:

B. E. Kirtner Coal Prospect—No. 778 on Map II.

Beaver Pond District, Mercer County; on the north side of East River 0.4 mile northeast of Ada; **Raines Corner Coal;** elevation, 2350′ B.; strata overturned and now dipping southeastward 45°; section from north to south in descending stratigraphic order.

		Ft.	In.
1.	Limestone, shaly, two or three streaks exposed in calcareous shale	30	0
2.	Sandstone, shaly, visible	5	0
3.	Concealed, with limestone carrying gastropods and brachiopods, **Raines Corner Limestone**	30	0
4.	**Coal,** rotten and shaly 1′ 3″ } **Raines Corner**		
5.	Shale, dark, **coaly**.... 1 0 } **Coal**	2	3
6.	Fire clay shale	..	..

A sample **(No. 634R)** was collected from No. 4 of section, the composition of which, as analyzed by Mr. Kaplan, will be found in the Table of Coal Analyses at the end of Chapter XIII. This sample contains 41.30 per cent. of ash, illustrating the generally poor quality of the Mauch Chunk coals.

Norfolk & Western Railway Coal Exposure—No. 779 on Map II.

Giles County, Virginia; on the east side of East River 0.1 mile south of Glenlyn; **Raines Corner Coal**; elevation, 1550′ B.; strata overturned and now dipping southeastward about 35 degrees; section from north to south in descending stratigraphic order.

		Feet.
1.	**Limestone, Raines Corner**, dark, with gastropods, brachiopods, and other marine fossils	25
2.	**Shale, Raines Corner**, dark, sandy	10
3.	Sandstone, hard, indurated	5
4.	**Coal, Raines Corner**, crushed and in pockets, thickness wholly indefinite	..
5.	**Shale, Possumtrot**, sandy	15
6.	**Sandstone, Droop**, shaly	30

In Monroe County the blossom is exposed at **Coal Exposure No. 780 on Map IV** in the road on Blue Lick Creek one mile west of Assurance at elevation 1700′ B., and at other points as follows:

Coal Exposure—No. 781 on Map IV.

Springfield District, Monroe County; on the north side of Indian Creek just west of Indian Creek School; **Raines Corner Coal**; elevation, 1575′ B.

		Ft.	In.
1.	**Limestone, Raines Corner**	5	0
2.	Concealed and calcareous shale, **Raines Corner Shale**	15	0
3.	Sandstone, shaly	10	0
4.	**Coal, Raines Corner**, very slaty	1	0
5.	Fire clay shale	..	..

At **Coal Exposure No. 782 on Map IV** on the east side of Hands Creek 0.7 mile south of Indian Creek School, Springfield District, it is visible in the public road at elevation 1630′ B., but is only a streak. In the Raines Corner Shale above it there are pelecypods, while 25 feet above the coal the Raines Corner Limestone is present carrying marine fossils as previously noted.

Coal Exposure—No. 783 on Map IV.

Springfield District, Monroe County; on a branch of Hands Creek 0.6 mile north of Assurance; **Raines Corner Coal**; elevation, 1925′ B.; dip, southeast, 15°.

		Ft.	In.
1.	Limestone, Raines Corner	5	0
2.	Concealed and sandy shale, Raines Corner Shale	20	0
3.	Coal blossom, Raines Corner	1	0
4.	Shale, Possumtrot, sandy	..	..

Coal Exposure—No. 784 on Map IV.

Springfield District, Monroe County; on a branch of Hands Creek 0.7 mile northeast of Assurance; Raines Corner Coal; elevation, 1905′ B.; dip, southeast, 5°.

		Ft.	In.
1.	Sandstone, shaly	10	0
2.	Shale, calcareous, with streaks of limestone, Raines Corner Limestone	10	0
3.	Slate, black, Raines Corner Coal	1	0
4.	Shale, Possumtrot, sandy, with plant fossils, to creek	4	0

At **Coal Exposure No. 785 on Map IV** on the north side of Indian Creek 0.8 mile northwest of Raines Corner the blossom of the coal is visible at elevation 1685′ B., slightly above the level of the county road.

An attempt was once made to mine this coal at the **Joseph Harvey Coal Prospect (No. 786 on Map IV)** in Springfield District on a ravine east of Rock Camp Creek and 0.4 mile southeast of Rock Camp village at elevation 1865′ B. According to Mr. Harvey not much coal was found, the prospect being now abandoned and fallen shut with only a few pieces of coal remaining on the dump.

Charles W. Copeland Coal Prospect—No. 787 on Map IV.

Springfield District, Monroe County; on Humphreys Run of Indian Creek 0.8 mile above its mouth and 1.4 miles east of Raines Corner; Raines Corner Coal; elevation, 1850′ B.; dip, northwest, 5°.

			Ft.	In.
1.	Limestone, Raines Corner, gray, shaly		5	0
2.	Concealed	10′		
3.	Shale, sandy, with lenses of limestone containing long pelecypods	5	Raines Corner Shale	21	0
4.	Slate, black	1		
5.	Shale, dark	5		
6.	Slate and coal, mixed, Raines Corner Coal		1	0
7.	Fire clay shale		..	..

Coal Exposure—No. 788 on Map IV.

Springfield District, Monroe County; in State road on west side of Indian Creek 1.4 miles northeast of Raines Corner; **Raines Corner Coal;** elevation, 1730′ B.; dip, southeast, 15°.

		Ft.	In.
1.	**Limestone, Raines Corner,** shaly, with marine fossils, gastropods (**Bellerophon**)	10	0
2.	**Shale, Raines Corner** (type locality), sandy, with marine fossils, long pelecypods and brachiopods	7	0
3.	**Coal, Raines Corner** (type locality), rotten	1	8
4.	**Shale, Possumtrot,** sandy, thickness concealed	..	..

The above exposure is the type locality both of the Raines Corner Coal and the Raines Corner Shale. It is the best exposure of the coal noted in the three counties but unfortunately the outcrop was too much oxidized to obtain a sample for chemical analysis.

Coal Exposure—No. 789 on Map IV and Local Measurement at Fossil Lot 229.

Springfield District, Monroe County; in road on west side of Indian Creek 1.6 miles northeast of Raines Corner; **Raines Corner Coal;** gentle southward dip; arranged in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (36′)			
1.	Sandstone, shaly, visible	5	5
2.	Concealed and limestone, **Raines Corner Limestone**	10	15
3.	**Shale, Raines Corner,** sandy, brecciated; contains plant fragments	10	25
4.	Shale, black, coaly, **Raines Corner Coal** (1735′ B.)	1	26
5.	**Shale, Possumtrot** (type locality), sandy, to road grade; contains plant fossils (see **Lot 229**)	10	36

Coal Exposure—No. 790 on Map IV.

Wolf Creek District, Monroe County; on Flint Hollow of Kelly Creek 0.3 mile northeast of Creamery; **Raines Corner Coal;** elevation, 1735′ B.; slight northwestward dip.

		Ft.	In.
1.	**Sandstone, Indian Mills,** partly shaly, but makes cliffs	30	0
2.	**Shale, Indian Mills,** green, argillaceous, with marine fossils, pelecypods; partly concealed	48	0
3.	**Coal, Raines Corner,** rotten at outcrop	1	8
4.	Concealed and sandy shale, **Possumtrot Shale,** to creek	10	0

The blossom of the coal may also be noted at another outcrop less than one-fourth mile farther up the hollow, at elevation 1745′ B.

In Summers County the coal was observed at **Coal Exposure No. 791 on Map VI** on the hill road which ascends the mountain on the north side of Greenbrier River 0.4 mile north of Pence Springs, at elevation 1555′ B., being only a streak or blossom, as recorded in the Pence Springs Section, page 254.

It is not apparent that this coal offers any hope whatever of commercial development and its use as a domestic fuel will be extremely limited, both because of its slaty character and on account of its thin bed section. At a few localities in western Monroe County it might possibly be used for the latter purpose.

POSSUMTROT SHALE.

The **Possumtrot Shale** (new) is a dark, sandy deposit varying from five to twenty-five feet in thickness and occurring just between the Raines Corner Coal and Droop Sandstone. Its type locality is in Monroe County on the west side of Indian Creek 1.6 miles northeast of Raines Corner and slightly north of Possumtrot Branch, as exhibited at **Coal Exposure No. 789 on Map IV,** page 413. Here the thickness exposed above the level of the State road is about 10 feet, the material being sandy and containing plant fossils. **Fossil Lot 229 on Map IV** was collected by Dr. David White, Mr. Price, and the writer, the discussion of its flora by Dr. White being found in Chapter XVII.

In the Wikel Section, page 221, the relationship of this shale to the higher members of the Bluefield Group is more fully indicated, and it may be observed at various other points beneath the outcrop of the Raines Corner Coal in the western part of Monroe County and the eastern edge of Summers. In Mercer County it can be seen in some of the gaps of Stony Ridge; and in the edge of Giles County, Virginia, it is 15 feet thick at **Coal Exposure No. 779 on Map II** on the east side of East River just south of Glenlyn as published on page 411.

DROOP SANDSTONE.

The **Droop Sandstone** (new) is usually a white, very coarse and soft ledge occurring 10 to 50 feet below the Raines Corner Limestone and having its base about 875 feet below the Stony Gap Sandstone in the region of maximum intervals in Mercer County but decreasing northward to less than 600 feet in the vicinity of Alderson. Its thickness at many localities is 40 to 60 feet and when it is developed on this massive scale it usually weathers out into white sand which becomes so deep in country roads passing over its surface that travel through it becomes quite difficult. In some localities, however, the stone is represented by a mere shell only five or ten feet thick, but it is seldom wholly absent. Its type locality is in Pocahontas County, West Virginia, on Droop Mountain in the vicinity of Spice, Mt. Zion Church, and West Droop School, where it makes the flat surface of the mountain for several miles along which much difficulty in travel has always been experienced, owing to the great quantity of weathered sand.

In Mercer County the Droop Sandstone is recorded in the Stony Gap Section of Chapter V, being 20 feet thick but much weathered, shaly, and wholly inconspicuous. East of this locality it may be observed at various points in the gaps of Stony Ridge, including the gap made by Twelvemile Creek, where it is visible one-third mile northwest of Ingleside, being 25 feet thick and making a nearly vertical reef. At **Coal Exposure No. 779 on Map II** in the edge of Giles County, Virginia, just south of Glenlyn, it is 30 feet thick, but shaly.

In Monroe County the Droop Sandstone is well developed at numerous localities, usually making a heavy, white cliff, which weathers to a coarse white sand. In the Bickett Knob and Elmhurst Sections its position with respect to the underlying formations of the Bluefield Group is clearly shown. In the southwestern part of the county it was noted at a road summit across a low ridge 0.7 mile southwest of Lindside and north of Dry Creek, at elevation 2035′ B., but here it is shaly, as is the case nearly all the way across southern Mercer, northern Giles, and southern Monroe Counties. On the north

side of Indian Creek about two miles west of Greenville there is a heavy cliff at elevation 1700′ B. that appears to be the Droop, although a special examination of the stratigraphic associations was not made to determine the point. On the head of Indian Draft it outcrops in the public road just south of Wayside, but is carried under the drainage of Stony Creek one-fourth mile west of Wayside, on account of the westward dip of the strata. East of Wayside it makes a heavy outcrop for more than a mile in the ridge road along the western flank of the Abbs Valley Anticline but on the axis of this fold it is above the topography. East of the anticline it soon reappears and makes a sandy road in the vicinity of Shady Grove Church; and just northward toward Sarton its base is at elevation 2490′ B. On Kelly Creek at Bethel Church just west of Creamery it is visible along the road at elevation 1660′ B., its dip being southeast toward the Creamery Syncline, and its condition shaly.

In the vicinity of Alderson along the road which ascends the hill southeastward toward Mt. Pleasant School it first outcrops less than one mile southeast of the town at elevation 2030′ B., where it makes a great white cliff 80 feet thick. From this point southward along the ridge road it rises toward the Mt. Pleasant Anticline and reaches an elevation of 2245′ B. at the southern end of the ridge about one mile northeast of Trinity Church. East of the Mt. Pleasant Anticline it descends with the structure and topography until it reaches the Laurel Creek Anticline 0.7 mile east of Mt. Pleasant School, its top being only 2090′ B. where the road crosses Laurel Creek. East of Laurel Creek it again rises eastward with the topography for more than two miles and apparently forms the escarpment of Flattop Mountain beyond which it is eroded. East of Alderson it is responsible for the deep gorge of Greenbrier River since it holds up the topography of Muddy Creek Mountain on the north, making a huge cliff along the southeastern front of this mountain, while on the south side of the river a similar escarpment is made at the northern end of Flattop Mountain.

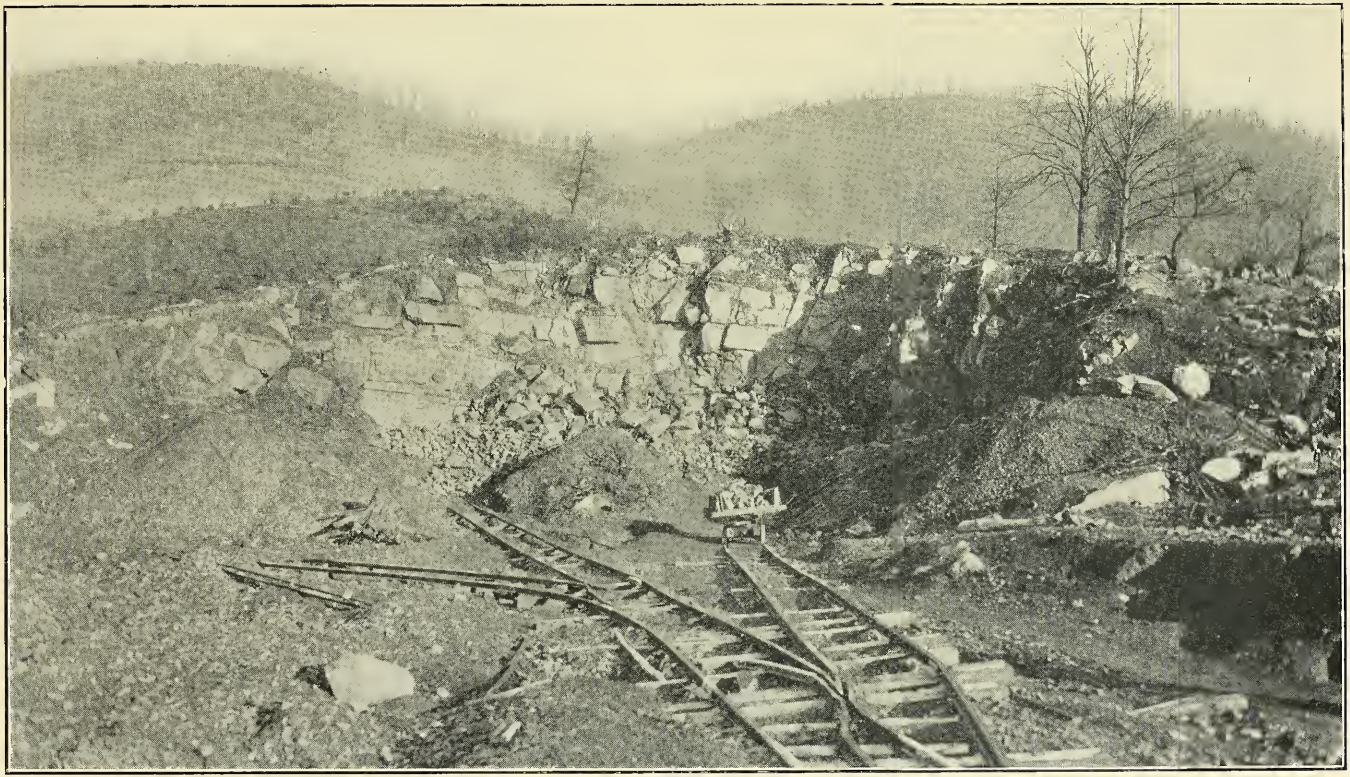

PLATE XXII.—Quarry of Crollins Stone Company in Union Limestone of Greenbrier Series at east end of Bluefield and just northwest of eastern highway bridge across N. & W. Railway tracks. Stony Ridge in background is made by almost vertical reef of Stony Gap Sandstone. Bluefield Group all exposed between quarry and ridge. (Photo. by Palmer & Fowler).

Farther south in the county it makes an extensive outcrop on the top of Swoopes Knobs, being there a massive white cliff 40 to 50 feet thick and weathering to coarse white sand. On this plateau it extends only slightly north of Knobs village, being prominent in the round hill just northeast of the village and being visible in a low hill one-third mile northwest of Knobs, at elevation 2940′ B., there being 25 feet of the rock not yet eroded. Farther west in the low hill one-third mile northeast of Reynolds School only a few boulders of it remain. South of Knobs in this same plateau the descending structure widens the outcrop to about one and one-half miles, the western escarpment being at Brown School from which point the rock may be noted eastward along the road nearly all the way to the eastern escarpment three-fourths mile northwest of Collins School. Plate IV shows a good view of this isolated tableland which is almost entirely preserved by the Droop Sandstone.

In Summers County the Droop Sandstone is recorded in the sections of Chapter V for Alderson, Glenray, Pence Springs, Green Sulphur Springs, and Warford, but at the latter two localities it is far under drainage, its thickness being noted in oil well records. At the locality of the Alderson Section it is 25 feet thick but makes a shaly cliff, while at the exposure of the Glenray Section on Griffith Creek in the vicinity of Santifee it is about 85 feet thick being partly massive and partly shaly at elevation 1610′ B. At Pence Springs it is shaly and only 20 feet thick, as exposed at the foot of the mountain road just north of the town. On the west side of Greenbrier River just west of Lowell it is visible in the river bluff at elevation 1580′ B., being a massive cliff 50 feet thick, as exhibited in the local measurements at **Fossil Lots 223 and 224 on Map VI** on a later page. On the road which crosses the low hills in the bend of Greenbrier River southwest of Lowell it is visible at elevation 1700′ B., but is shaly and much weathered out. On the south side of the river west of the Alderson Anticline it rises above drainage just southeast of Talcott and ascends southeastward with the topography to the top of Wind Creek Mountain, being exhib-

ited in the local measurement at **Fossil Lot 188 on Map VI,** there being a visible thickness of 20 feet as published on a later page. Just to the eastward the sandstone is broken by the Talcott Fault in the northern front of Wind Creek Mountain as described on pages 183-184. On the southern side of Wind Creek Mountain the structure descends southeastward so that the rock forms the dip slope along the country road east and west of Crossroads School, but toward Bargers Springs it passes under drainage in the vicinity of **Fossil Lot 186 on Map VI** as previously indicated on page 408.

So far as known the Droop Sandstone has not been quarried and it is doubtful whether it could be used for masonry with any success since it contains little cementing material and is always too soft for such purposes. In northern Monroe County, however, it has the appearance of an ideal glass-sand, being almost free from iron or other coloring agents and having no quartz pebbles. It could be quarried without limit in the ridges just southeast of Alderson and could be carried by gravity plane down to the Chesapeake and Ohio Railway. In Swoopes Knobs it could also be easily quarried but railroad transportation in that region is not available.

The writer is much inclined to believe that the Droop Sandstone is the same as the Maxton Oil Sand, which in the central and northwestern counties of this State occurs in the lower part of the Mauch Chunk Series, but which has never been positively identified at any outcrop because of the great southeastward increase in the intervals of this series. The soft and porous nature of the Droop would make it an ideal oil and gas reservoir in regions where it is deeply buried under drainage, as is not the case in the three counties under study. It is of course quite possible that the Stony Gap Sandstone instead of the Droop may be the Maxton but its hardness and lack of pore space does not favor such a view.

TALCOTT SHALE.

The **Talcott Shale** (new) is a gray and sandy deposit coming just below the Droop Sandstone and usually varying from

15 to 25 feet in thickness and often containing rather abundant marine fossils, among which brachiopods, pelecypods, bryozoa, and cephalopods have been noted. It is usually distinguished from the underlying Ada Shale by a more grayish color as contrasted to green, by its sandy character as compared to the calcareous nature of the Ada, and by a considerable difference in the fauna, the variation being so evident that a slight disconformity may be assumed as well as the possible intervention of another formation in some region not yet explored. It is the writer's opinion that the Talcott Shale is of the approximate age of the higher portion of the Clore Formation in western Kentucky and if that be true it would of course correlate by inference with some portion of the same formation at its type locality in Randolph County, Illinois, the Clore Formation being the youngest member of the Chester Series as described in those two States. It is possible, however, that the Raines Corner Limestone with its abundant **Bellerophon** may also belong with the Clore but the intermediate Droop Sandstone, which covers such a large extent in southern West Virginia, and the Raines Corner Coal, which also has a considerable areal distribution, both present a considerable argument against including the Raines Corner Limestone and Talcott Shale in the same stage.

The type locality of the Talcott Shale is in Summers County on the south side of Greenbrier River 0.6 mile southeast of Talcott where it is exposed in the public road as exhibited in the following local measurement:

Local Measurement at Fossil Lot 188.

Talcott District, Summers County; along road on south side of Greenbrier River 0.6 mile southeast of Talcott; gentle northwest dip; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (40′)		
1. **Sandstone, Droop,** massive, visible	20	20
2. Concealed	5	25
3. **Shale, Talcott** (type locality), green, argillaceous (1515′ B.); contains a ferruginous streak having marine fossils, brachiopods and pelecypods (see **Lot 188**)	15	40

Fossil Lot 188 on Map VI was collected at the above locality by Dr. Girty and the writer, the more detailed discussion of which by the former will be found in Chapter XVIII.

In the same county this shale is recorded in the Alderson Section, page 258, being green, sandy, and 15 feet thick; and in the Glenray Section, page 255, where it has the same thickness.

In Mercer County, it should be present in some of the gaps of Stony Ridge and at other southern points but no search was made for it after it had been differentiated farther north.

In Monroe County it is recorded in the Bickett Knob Section, page 223, being exposed at elevation 2925′ B. just below a 25-foot outcrop of the Droop Sandstone one-third mile northwest of Knobs, where the writer collected **Fossil Lot 182 on Map IV**, the discussion of which by Dr. Girty will be found in Chapter XVIII. On the head of Indian Draft 0.3 mile south of Wayside it is visible at elevation 1860′ B., being green, sandy, 25 feet thick, and containing a few marine fossils. On the hill road west of Wolf Creek at 1.8 miles northeast of Wayside the following observation was made:

		Feet.
1.	**Sandstone, Droop,** massive at top, shaly at base...	15
2.	**Shale, Talcott,** green and sandy, with numerous marine fossils including pelecypods and brachiopods (1870′ B.)	10
3.	**Sandstone, Webster Springs,** calcareous and shaly.	15
4.	**Limestone, Glenray,** gray, hard, with marine fossils; brachiopods (including **Orthotetes**), crinoids and bryozoa (including **Archimedes**), (dip, northwest, 25°)	40

At the above locality there appears to be no Ada Shale, the Talcott being recognized by the abundance of pelecypods as contrasted to their almost total absence in the Ada. On the hill road 0.7 mile southeast of Alderson the shale is visible at elevation 2005′ B., just below the gray cliff of the Droop Sandstone, being sandy, 25 feet thick, and containing brachiopods, while just below it the green, calcareous Ada Shale is visible. In the road at Chestnut Ridge School on the west

side of Flattop Mountain it is again exposed at elevation 2570′ B., just below the Droop Sandstone, being greenish-gray, and containing pelecypods and brachiopods.

ADA SHALE.

The **Ada Shale** (new), belonging just below the Talcott Shale and only 10 to 25 feet below the Droop Sandstone, is an olive-green, fissile deposit usually argillaceous at the top and calcareous toward the base, varying in thickness from 30 to 60 feet and almost invariably having abundant marine fossils, among which fenestelloid bryozoa are very common and brachiopods, including **Spirifer** and **Productus,** are also numerous, pelecypods being noted only at infrequent points. This shale is usually quite easily recognized both because of its peculiar green color and by the great abundance of the fenestelloids, which are extremely rare in the higher members of the Bluefield Group, while in the underlying formations there are other features which make them distinctive from the Ada Shale as will be later described. This member may be recognized at almost any point in the three counties where its horizon outcrops. The writer is of the opinion that it is of the same age as part of the Clore Formation as described in western Kentucky and that it would therefore correlate with some portion of this stage at its type locality in Randolph County, Illinois.

The type locality of the Ada Shale is in Mercer County on the north side of East River in the public road between Ada and Stony Gap and less than one-fourth mile west of the former point, as exhibited at the following local measurement:

Local Measurement at Fossil Lots 43A, 251, and 252.

Beaver Pond District, Mercer County; along road between Stony Gap and Ada, starting 0.5 mile west of Ada and traversing eastward 0.3 mile along quarter strike of overturned strata; actual dip, southeastward; arrangement in descending stratigraphic order; thicknesses estimated.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (70′)			
1.	Shale, yellow, sandy	..	..
2.	**Limestone, Raines Corner,** shaly (2405′ B.); contains marine fossils, brachiopods (especially **Orthotetes** and **Diaphragmus**) and gastropods (see **Lot 252**)	5	5
3.	**Sandstone, Droop,** shaly, ripple-marked	10	15
4.	Limestone, gray, hard, sandy, with marine fossils.	5	20
5.	**Shale, Ada** (type locality), yellow and calcareous, contains abundant marine fossils, fenestelloid bryozoa, brachiopods, crinoids, pelecypods, etc. **Lot 43A** was collected from Nos. 2, 4, and 5 of section. Another collection was made from No. 5 only of section (see **Lot 251**)	50	70

At the above locality Dr. Prouty and the writer collected **Fossil Lot 43A on Map II** from Nos. 2, 4, and 5 of section, this work being done before any differentiation of the members had been made. This lot was forwarded by Dr. Prouty to Dr. E. M. Kindle who appears to have been unable to give it attention. At a subsequent visit, after the subdivision of the Bluefield Group had been made, the writer collected **Fossil Lot 251 on Map II** from the Ada Shale alone, the fauna of which will be described by Dr. Girty in Chapter XVIII. At this locality the shale contains vast numbers of fenestelloid bryozoa.

In the same county the shale is visible along the Bluefield-Princeton road 0.4 mile southwest of Stony Gap as exhibited in the Stony Gap Section, page 198, and as illustrated by Plate XVI in connection with the Reynolds Limestone from which it was not differentiated at that point. Here the shale and limestone are together 78 feet thick and contain abundant fenestelloids and some brachiopods. It is possible that the whole exposure should be called Ada Shale since some of the common fossils of the Reynolds Limestone were not noted but the calcareous lower portion is the only zone that could represent the Reynolds Limestone along this road. At this point the writer collected **Fossil Lot 120 on Map II,** the detailed report of which by Dr. Girty will be found in Chapter XVIII.

In the edge of Tazewell County, Virginia, the shale is exposed 0.3 mile northeast of the new railroad station at Graham

(now Bluefield, Virginia), and only slightly north of the highway underpass beneath the Norfolk & Western Railway, being green, calcareous, and containing fenestelloids and other marine fossils, the angle of its dip being approximately 90°.

In the eastern part of Mercer County it is visible in the road on the north side of Twelvemile Creek just west of Ingleside, being green, calcareous and containing numerous fenestelloids together with crinoids, pelecypods, and brachiopods, and being overturned and now dipping south at an angle of 80 degrees. In the edge of Giles County, Virginia, it is recorded in the Glenlyn Section, page 203, being 50 feet thick, olive-green and calcareous and containing marine fossil fragments.

In Monroe County it was observed by Dr. Prouty and the writer on Trigger Run 0.1 mile south of the intersection of the Trigger Run road with the State road and 1.8 miles east of Peterstown, being apparently more than 50 feet thick, yellow, and calcareous, and containing fenestelloids. Here the dip of the overturned strata is now southward at an angle of 40 degrees. Slightly farther west in the State road north of Trigger Run 1.1 miles east of Peterstown it is again visible, being green, calcareous, and containing numerous brachiopods and a few fenestelloids, its dip there being southward at an angle of 45 degrees. On the State road between Peterstown and Lindside it is exposed 0.6 mile southeast of Brick Church at elevation 1900′ L., being green and containing impure fossiliferous limestone with crinoids, brachiopods, and fenestelloids, with its overturned strata now dipping southward at an angle of 55 degrees.

Farther east it was observed by Mr. Price and the writer on a cross-road from Dry Creek to Mud Run 0.8 mile southwest of Lindside and 0.2 mile north of the State road, at elevation 2010′ B., being green, fissile, and 50 feet thick, and containing brachiopods, including **Spirifer pellaensis** and **Diaphragmus**, together with **Orthoceras** and fragments of an unknown bryozoon. On Dropping Lick it is exposed on the north side of the road 1.9 miles northeast of Rock Camp village at elevation 1890′ B., consisting of green shale and shaly

limestone and containing numerous brachiopods. On Indian Creek it is well exposed in the county road on the northwest side of the creek 2.4 miles northeast of Raines Corner, being green, calcareous, and about 50 feet thick, and containing fenestelloids and brachiopods, among which **Spirifer** is especially abundant. Here Dr. Girty and the writer collected **Fossil Lot 154 on Map IV,** as listed in more detail by Dr. Girty in Chapter XVIII.

Farther down Indian Creek it is again prominent at **Fossil Lot 216 on Map IV** in the road and field on the north side of the creek 1.1 miles northwest of Raines Corner. The fauna at this point, as collected by Dr. Girty and the writer, and as described in more detail by the former in Chapter XVIII, is largely brachiopods, especially **Productus inflatus,** together with some mollusks. On the head of Cooks Run 0.1 mile north of Raines Corner School and 2.1 miles south of Greenville it is visible at elevation 1875′ B. in the road, being partly green, sandy shale and partly shaly limestone. Here it contains brachiopods and horn corals. On a branch of Hands Creek 0.3 mile west of the mouth of Blue Lick and 1.7 miles west of Assurance it occurs in the road at elevation 1715′ B., the exposure being 10 feet thick and consisting of green shale with streaks of ferruginous and fossiliferous limestone containing brachiopods and small, short pelecypods.

On the ridge road from Wayside to Sarton it is exposed at elevation 2545′ B., one mile southeast of the former village, consisting mostly of shaly limestone containing brachiopods and pelecypods, its dip being southwestward at an angle of 10 degrees. On the road at Bethel Church on Kelly Creek just west of Creamery it is green and calcareous, at elevation 1650′ B., with a visible thickness of 30 feet, and contains brachiopods (including **Spirifer pellaensis**), bryozoa, and a species of horn coral. On the hill road southeast of Alderson it is exposed at elevation 1985′ B., being 20 feet thick and separated from the great Droop Sandstone cliff by 25 feet of Talcott Shale. Here it is a green, calcareous shale and contains pelecypods, brachiopods, and gastropods. On the Flattop Mountain road 0.2 mile southeast of Chestnut Grove School it is

exposed at elevation 2610′ L., its color being olive-green. At the northern end of the same mountain it is visible in the road 0.4 mile southwest of Mt. Vernon School at elevation 2205′ B., being green and calcareous. On the road from Lillydale to Lick Creek it occurs at the summit of the ridge 0.5 mile southeast of Lillydale at elevation 2010′ B., being green and calcareous and containing **Archimedes** and other bryozoa, together with brachiopods, among which **Spirifer pellaensis** was noted. At this point it dips southeast at an angle of 15 degrees. On the Knobs-Salt Sulphur Springs road 1.4 miles south of Knobs it outcrops at elevation 2855′ B., being green and 35 feet thick, with some streaks of limestone in which there are numbers of **Spirifer pellaensis.** In the same region it is recorded in the Bickett Knob Section, page 223, being green, fissile, and calcareous and containing numerous marine fossils which are largely brachiopods and bryozoa. Here Dr. Girty and the writer collected **Fossil Lot 181 on Map IV,** as listed in more detail by Dr. Girty in Chapter XVIII. This exposure is in the public road one-third mile northeast of Knobs village. Its stratigraphic associations in the same locality are also exhibited in the Elmhurst Section, page 222.

In Summers County the Ada Shale is recorded in the Alderson Section, page 258, being 60 feet thick, green, calcareous and containing marine fossils including brachiopods and bryozoa and its presence is also indicated in the Green Sulphur Springs Section, page 241, as revealed by an oil well record.

On the north side of Greenbrier River it is visible in the road 0.6 mile northeast of Pence Springs town at elevation 1520′ B., being green and calcareous, and containing crinoids, bryozoa, and brachiopods (including **Spirifer pellaensis**). Farther west it is well displayed at the following local measurement:

Local Measurement at Fossil Lots 223 and 224.

Talcott District, Summers County; in bluff on the west side of Greenbrier River 0.3 mile west of Lowell; rapid northwest dip; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (165′)		
1. **Sandstone, Droop,** massive, cliff rock (1580′ B.)..	50	50
2. **Shale, Ada,** green, calcareous; contains numerous marine fossils, brachiopods and bryozoa (including **Archimedes**) (see **Lot 223**).....	50	100
3. **Limestone, Reynolds,** shaly (1515′ B.); contains marine fossils, brachiopods (see **Lot 224**).....	15	115
4. **Limestone, Glenray,** partly hard and partly shaly, visible	50	165

At the above locality Dr. Girty and the writer collected **Fossil Lot 223 on Map VI** from the Ada Shale, the detailed report of which by Dr. Girty will be found in Chapter XVIII. On the descending structure farther west it is visible in the field south of the Pence Springs-Talcott road and north of the bend of Greenbrier River 0.8 mile southwest of Lowell at elevation 1675′ B. Here it was observed by Dr. Girty and the writer to be green, calcareous, and 25 feet thick, coming just under a shaly exposure of the Droop Sandstone and containing pelecypods, brachiopods (including **Spirifer pellaensis, Reticularia,** and **Diaphragmus**), together with bryozoa and other forms.

In its more extended relationships the Ada Shale may be traced northeastward in West Virginia nearly to the head of the Greenbrier Valley and possibly all the way to southern Pennsylvania, although there is still doubt in the more northern region. Southwestward it may be easily recognized at various points in southwest Virginia and may also be followed far down into the State of Tennessee, being quite typical at Daisy in Hamilton County. It has no economic significance but as a correlation plane it is of much importance.

REYNOLDS LIMESTONE.

The **Reynolds Limestone** (new) is a gray, shaly bed usually 10 to 15 feet in thickness but occasionally heavier, coming immediately under the Ada Shale and being invariably rich in marine fossils. Its fauna consists principally of brachiopods among which a large species of **Orthotetes** is especially prominent and by its abundance and almost invariable pres-

ence affords a good clue toward the identification of the bed, although it is not entirely diagnostic. Besides the brachiopods there are bryozoa, gastropods, and occasional cephalopods, but few, if any, pelecypods have been noted. In physical character this limestone is almost wholly nondescript but its fauna and stratigraphic associations are such that it should seldom be mistaken by an experienced observer. Its type locality is in Monroe County on the western escarpment of the Swoopes Knobs plateau in the public road 0.3 mile eastward from Reynolds School and 0.6 mile northwest of Knobs village. Here, as exhibited in the Bickett Knob Section, page 224, and Elmhurst Section, page 222, it is shaly, 15 feet thick, and contains numerous marine fossils, chiefly brachiopods among which **Orthotetes** is abundant, and it also has plant fossils. At this point **Fossil Lot 180 on Map IV** was collected from the marine fossils found by the writer, the detailed list of which by Dr. Girty will be found in Chapter XVIII.

In Mercer County this limestone is indicated in the Stony Gap Section, page 198, but is not therein differentiated from the Ada Shale, since it is extremely shaly and hardly shows a representative fauna so that its identification is in doubt. **Fossil Lot 120 on Map II** was collected from the combined exposure by the writer, the detailed list of which by Dr. Girty will be found in Chapter XVIII. Plate XVI shows a view of this outcrop. In the Nemours Station Section, page 189, the limestone is noted as gray and three feet thick, with marine fossils and coming just above the red Bickett Shale which is a very dependable marker when present. In the edge of Giles County, Virginia, it is recorded in the Glenlyn Section, page 203, being 15 feet thick, shaly, and containing brachiopods.

In Monroe County, besides its type locality as already described, it is visible at elevation 1995′ B. along a cross-road from Dry Creek to Mud Run, 0.8 mile southwest of Lindside and 0.1 mile north of the State road, where, as observed by Mr. Price and the writer, it contains some very large **Orthotetes**, the strata at this locality being overturned and now dipping southward. On a branch of Rock Camp Creek 0.8 mile south-

west of Rock Camp village it is exposed in the State road at elevation 1890′ B., being 10 to 15 feet thick, shaly, and overturned, with a present dip of 40 degrees southeastward. Here there are abundant marine fossils, mostly brachiopods, among which **Orthotetes** occurs. On the west side of Indian Creek 2.5 miles northeast of Raines Corner it is visible at elevation 1745′ B. in the road and bluff, being shaly, 75 feet thick, and dipping southward at an angle of 30 degrees, with a varied fauna, among which there are many brachiopods (including **Spirifer** and **Orthotetes**), together with bryozoa and crinoids and what appeared to be a fragment of a trilobite. Here the writer collected **Fossil Lot 157 on Map IV,** the more detailed list of which by Dr. Girty will be found in Chapter XVIII.

On the Turkey Creek road it may be noted on either side of the Hurricane Ridge Syncline, there being a good exposure on the south side of this basin at a point 1.2 miles southward from Salt Sulphur Springs at elevation 1820′ B., where it is shaly and contains abundant brachiopods among which **Orthotetes** was noted, there being bryozoa (**Archimedes**), and crinoids. Here the writer collected **Fossil Lot 156 on Map IV,** as reported in more detail by Dr. Girty in Chapter XVIII. Farther down Indian Creek it is visible at elevation 1745′ B. in the road north of the creek and 1.4 miles northwest of Raines Corner, being shaly and containing many brachiopods, among which there are large **Orthotetes,** together with gastropods, crinoids, and cephalopods (**Orthoceras** and a nautiloid), and other forms. Here Dr. Girty and the writer collected **Fossil Lot 217 on Map IV,** the more detailed report of which by the former will be found in Chapter XVIII.

On the head of Cooks Run of Indian Creek 0.2 mile north of Cooks Run School and 2.2 miles south of Greenville it is visible at elevation 1875′ B., being shaly, 30 feet thick, and containing **Orthotetes** and other brachiopods, together with the bryozoon **Archimedes.**

West of the Abbs Valley Anticline it is exposed at elevation 2620′ B. on the ridge road between Wayside and Sarton 1.5 miles southeast of the former, being shaly and containing brachiopods (including a small **Orthotetes**), and gastropods.

On the Kelly Creek road 0.8 mile northwest of Creamery it is exposed at elevation 1600′ B., being shaly and containing many brachiopods (including **Composita** and a large **Orthotetes**), and also small gastropods. On the road across the southern end of Flattop Mountain 0.3 mile southeast of Chestnut Grove School it occurs at elevation 2620′ B., being shaly, and containing large **Orthotetes** together with other brachiopods; and on the road across the northern end of the same mountain it is visible at elevation 2160′ B., 0.3 mile southwest of Mt. Vernon School, being shaly and having brachiopods. In the extreme top of Bickett Knob northwest of Union it is imperfectly exposed, as recorded in the Bickett Knob Section, page 224, but contains brachiopods and bryozoa. Here the writer collected **Fossil Lot 168 on Map IV**, the detailed study of which by Dr. Girty appears in Chapter XVIII. On the southern end of Swoopes Knobs it is exposed at elevation 2790′ B. on the Knobs-Salt Sulphur Springs road 1.5 miles south of Knobs, being 30 feet thick, shaly, and containing numerous **Orthotetes** and other brachiopods.

In Summers County the horizon of the Reynolds Limestone is concealed at the Alderson Section, page 258, but at the Glenray Section, page 255, it is 25 feet thick and very shaly, as exposed on Griffith Creek, and contains numerous large pelecypods, together with brachiopods. This identification, however, is somewhat in doubt since the Ada Shale was not found above it, and since pelecypods were found in the limestone instead of the usual **Orthotetes**. It is possible that the exposure represents a more calcareous occurrence of the Ada Shale than is usually found. In the Green Sulphur Springs Section, page 241, there is a black limestone 15 feet thick that appears to represent the Reynolds Limestone, as recorded in an oil well record.

On the west side of Greenbrier River, 0.3 mile west of Lowell it is well exposed at elevation 1515′ B., being shaly and containing marine fossils, principally brachiopods. Here Dr. Girty and the writer collected **Fossil Lot 224 on Map VI**, as listed in more detail by the former in Chapter XVIII. The strata at this point are exhibited in a local measurement at

Fossil Lots 223 and 224 under the discussion of the Ada Shale, page 426.

The Reynolds Limestone appears to be everywhere too shaly and impure for economic use, except as a soil maker or possibly as a mixing agent in the manufacture of Portland cement, when it is desired to reduce the high lime content of other formations that are too pure to be used alone. It has a very great scientific interest, however, in connection with the eventual correlation of the members of the Mauch Chunk Series with those of the Chester in the Mississippi Valley, and its rich fauna was studied extensively in Monroe County with that end in view. The writer is of the opinion that its age is the same as the lower part of the Clore Formation in western Kentucky and Illinois.

BICKETT SHALE.

The **Bickett Shale** (new) is usually a red and argillaceous but occasionally sandy deposit, varying in thickness from 5 to 25 feet and belonging between the Reynolds Limestone and Webster Springs Sandstone and being of almost constant occurrence at the horizon of its outcrop in the three counties. Because of its color it is of much value as a correlation plane since it is the only red member between the Indian Mills Shale and the base of the Bluefield Group. Its type locality is in Monroe County on the northwestern angle of Bickett Knob at elevation 3285′ B., being 30 feet thick, red and sandy, as exhibited in the Bickett Knob Section, page 224. It is also visible on the western rim of the Swoopes Knobs plateau, being 15 feet thick, as recorded in the Elmhurst Section, page 222. On the road across the southern end of Flattop Mountain 0.3 mile southeast of Chestnut Grove School it is exhibited at elevation 2520′ B., being red and occurring between the Reynolds Limestone and Webster Springs Sandstone.

In Mercer County the shale is noted in the Nemours Station Section, page 189, being red and variegated and 15 feet thick. In the edge of Giles County, Virginia, it is recorded in

the Glenlyn Section, page 203, where it is ten feet thick and sandy. In Summers County its horizon is concealed both at the Alderson and Glenray Sections. At various other points in the three counties it may be observed in the county roads at its proper stratigraphic position.

WEBSTER SPRINGS SANDSTONE.

The **Webster Springs Sandstone** of the writer[18] is a greenish-gray, flaggy or shaly, fine-grained ledge, varying in thickness from five to ten feet but being quite constant in the region of its outcrop in the three counties. At its type locality in Webster County it is 50 to 75 feet thick, making bluffs and cataracts along Elk River just above Webster Springs. The position of this sandstone with respect to other members of the Bluefield Group is suggestive of the Palestine Sandstone of Randolph County, Illinois, as first described by Weller[19], and as later traced by Butts[20], and others into western Kentucky. An actual correlation can not be assumed, however, since it appears to contain no marine fossils and few plants, but its position just above the Glenray Limestone of probable Menard age is most interesting.

In Mercer County the Webster Springs Sandstone is recorded in the Nemours Station Section, page 189, being five feet thick and shaly, and in the edge of Giles County, Virginia, it is noted at the Glenlyn Section, page 203, being flaggy and ten feet thick. In Monroe County it is visible near the top of Bickett Knob, being five feet thick, green, and flaggy, as exposed in the Bickett Knob Section, page 224. At the southern end of Swoopes Knobs it is exposed at elevation 2725′ B. on the Knobs-Salt Sulphur Springs road 1.6 miles south of Knobs, being 65 feet thick and shaly. On the hill road west of Wolf Creek 1.8 miles northeast of Wayside it is 15 feet thick, calcareous, and shaly at elevation 1855′ B., as published in a local

[18]David B. Reger, Webster Report, W. Va. Geol. Survey, pp. 227-228; 1920.

[19]Stuart Weller, Mon. 1, Ill. Geol. Survey, p. 29; 1914.

[20]Charles Butts, Mississippian Formations of Western Kentucky, Ky. Geol. Survey, p. 109; 1918.

measurement under the discussion of Talcott Shale, page 420. On the road across the southern end of Flattop Mountain 0.4 mile southeast of Chestnut Grove School it is visible at elevation 2610′ B., being shaly. On Cooks Run of Indian Creek 0.4 mile northeast of Cooks Run School and 1.9 miles south of Greenville it is visible at elevation 1845′ B., being massive but having some green shale in the upper portion, the entire thickness being 35 feet.

In Summers County it is recorded in the Glenray Section, page 255, being five feet thick and massive. This exposure is visible on the northwest side of Greenbrier River just north of the mouth of Griffith Creek where it comes just above the thick ledge of the Glenray Limestone as exhibited in Plate XVII. On the Lowell-Creamery road in the flats one mile east of Lowell it again occurs at elevation 1745′ B., being shaly.

So far as known the Webster Springs Sandstone has not been quarried in the three counties, and as a rule it is not fitted for building material in this region, but is a valuable marker in the correlation of the lower members of the Bluefield Group.

GLENRAY LIMESTONE.

The **Glenray Limestone** (new), coming just below the Webster Springs Sandstone and only 100 to 125 feet above the base of the Bluefield Group, is a gray and usually hard and somewhat sandy, but sometimes shaly, formation varying in thickness from 80 to 125 feet, and containing numerous marine fossils, chiefly brachiopods, together with a few bryozoa (including **Archimedes**), crinoids, horn corals, occasional fish teeth and perhaps other classes. Its type locality is in Summers County in the northwestern side of Greenbrier River opposite Glenray and just north of the mouth of Griffith Creek where it makes a prominent ledge 75 feet thick just above the level of Greenbrier River, as exhibited by Plate XVII, and as recorded in the Glenray Section, page 255. Here Dr. Girty and the writer collected **Fossil Lot 219 on Map VI** there being brachiopods, crinoids, and bryozoa, including fairly abundant **Archimedes**, as listed in more detail by the former in Chapter

PLATE XXIII.—Typical sink-hole in Greenbrier Series 1½ miles southeast of Sinks Grove, Monroe County, along the road toward Pickaway. Outlet of hole is now filled, ponding water. (Photo. by Palmer & Fowler).

XVIII. It is noted at outcrop also in the Alderson Section, page 258, being 75 feet thick; and in the Warford Section, page 262, it is identified in a well record with a thickness of 50 feet, and in the Green Sulphur Springs Section, page 241, it is named in another well record with a thickness of 65 feet.

In the same county it may be observed at several points along the Alderson Anticline. On the hill road from Lowell to Riffe it is visible at elevation 1610′ B., three-fourths mile southwest of Riffe, its thickness being about 100 feet and its character hard. On the north side of Greenbrier River it is again exposed in a private road one-half mile northwest of Riffe, the elevation of its top being 1540′ B. Here it is somewhat massive and impure and has the Webster Springs Sandstone just above it. Farther down the river it is exposed on the west side 0.3 mile west of Lowell, there being a visible thickness of 50 feet, as exhibited in the local measurement at **Fossil Lots 223 and 224 on Map VI** under the discussion of the Ada Shale, page 426. South of the river it is exposed in the Lowell-Creamery road 0.8 mile southwest of Lowell at elevation 1670′ B., coming just over the black Lillydale Shale and having crinoids, brachiopods, and blastoids **(Pentremites).**

In Mercer County the Glenray Limestone is visible on the eastern slope of the Abbs Valley Anticline in the cut of the Norfolk & Western Railway between Nemours Station and Nemours village, as exhibited in the Nemours Station Section, page 189. Here it has a total thickness of 44 feet, being composed of limestone interstratified with gray and dark shale and containing near the middle a lenticular coal **(Nemours Coal)** and having marine fossils.

In the edge of Tazewell County, Virginia, it is again visible in the cut of the Norfolk & Western Railway about one-fourth mile northwest of the new railway station at Graham (now Bluefield, Virginia), and just west of the Stony Ridge Fault. Here it is quite shaly but is 115 feet thick and contains abundant marine fossils from which Dr. Prouty and the writer collected **Fossil Lot 14 on Map II,** the fauna of which is discussed by Dr. Girty in Chapter XVIII.

At the Waugh Siding Section, measured at the western edge of Bluefield and published on page 192, its horizon is occupied entirely by sandy shale and this is also the case at the Stony Gap Section, page 198, there being no vestige of limestone where it should occur. Farther east, however, it reappears in the edge of Giles County, Virginia, as recorded in the Glenlyn Section, page 203, but here it is only ten feet thick and shaly, with marine fossils among which bryozoa were noted. A few miles farther east it reaches a thickness of 120 feet where the Princeton-Narrows road crosses the Norfolk & Western Railway southeast of Lurich, being shaly and containing marine fossils, but having a poor exposure.

In Monroe County it occurs on the east side of Rock Camp Creek 0.6 mile south of Rock Camp village, its thickness being somewhat uncertain owing to the disturbed nature of the strata in that locality. Here Mr. Price and the writer collected **Fossil Lot 255 on Map IV,** consisting of a loose boulder which had evidently rolled down from the outcrop in the ridge above, and near the contact of the Mauch Chunk and Greenbrier Series. It can not be stated with certainty that this boulder comes from the Glenray Limestone but this is its most probable origin. Among other fossils the collection contains brachiopods and a fairly well preserved fish tooth, as listed by Dr. Girty in Chapter XVIII.

On the waters of Back Creek 0.4 mile northwest of Lillydale this limestone is exposed in the sharp turn of the road at elevation 1910′ B., coming just over the black Lillydale Shale and having a visible thickness of 30 feet, and containing marine fossils, among which crinoids and brachiopods were noted. A little farther west it is again visible 0.7 mile northwest of Lillydale and 0.1 mile southeast of the point where the Lillydale road intersects the Laurel Creek road, there being a partial exposure at elevation 1910′ B. Here it is shaly toward the top and contains marine fossils among which brachiopods, crinoids and "Winged pelecypods" are recorded in the notes of the writer. Most unfortunately this pelecypod was not collected for study, since it was probably a species of **Sulcatopinna** which is largely confined to the Menard Limestone and

the lower portion of the Clore Formation of the Mississippian. That being the case a collection from this locality would be of very much interest.

On Indian Creek northwest of Raines Corner the Limestone is exposed in the road 0.7 mile east of Hunter Springs School and just south of the point where a private road turns northward from the highway, the elevation of its top being 1755′ B. Here it is a hard, blue limestone, 50 feet thick, and contains marine fossils among which brachiopods are numerous, and there are also bryozoa **(Archimedes)** and gastropods. On the head of Indian Draft 0.7 mile south of Wayside it is visible at elevation 1735′ B., coming just over the greenish-black Lillydale Shale and being shaly, its thickness not having been noted.

Farther northwest it is visible on Kelly Creek at the road fork 1.1 miles northwest of Creamery, being a hard limestone of which only the top portion is exposed at elevation 1595′ L. On a branch of Wolf Creek near the eastern base of Wolf Creek Mountain and 1.3 miles northwest of Elmhurst it is exposed at elevation 1700′ B., being a massive ledge and containing **Archimedes** and being covered by the shaly Webster Springs Sandstone. Farther north it is exposed at elevation 2010′ B., on the hill road 1.5 miles north of Wolf Creek Post-office, being hard, and coming just over the green Lillydale Shale, and having marine fossils among which brachiopods, crinoids, and horn corals were noted.

This limestone may be studied to great advantage in the plateau of the Swoopes Knobs west of Union where it outcrops in full thickness at several localities. In the Bickett Knob Section, page 224, it is 125 feet thick at elevation 3155′ B. along the northwestern angle of the knob, and contains marine fossils, chiefly brachiopods, with some bryozoa (including **Archimedes**), and crinoids. Here the writer collected **Fossil Lot 169 on Map IV,** the more detailed report of which by Dr. Girty will be found in Chapter XVIII. On the west side of the plateau slightly northwest of Reynolds School and 0.7 mile northwest of Knobs it is exposed at elevation 2860′ B., as exhibited in the Elmhurst Section, page 222, and contains

marine fossils, mostly brachiopods, with some bryozoa, including **Archimedes.** Here Dr. Girty and the writer collected **Fossil Lot 215 on Map IV,** as listed in detail by the former in Chapter XVIII. Farther south on the same side of the plateau it is again visible in the road 0.4 mile northwest of Brown School, being shaly and coming under the shaly Webster Springs Sandstone with the contact at elevation 2710′ B. Here its thickness is about 70 feet and it contains brachiopods (including **Orthotetes),** bryozoa **(Archimedes),** horn corals, and crinoids. On the southern end of the plateau it is exposed at elevation 2605′ B., in the Knobs-Salt Sulphur Springs road 1.8 miles south of Knobs, being partly gray and partly dark, hard, and impure and having a thickness of 120 feet, not all of which is visible. Here its marine fossil content is abundant, there being brachiopods (including **Orthotetes),** bryozoa (including **Archimedes),** crinoids, and possibly other types.

Farther north in West Virginia the Glenray Limestone has probably often been called the "Little Lime" by oil well drillers, as is the case in the records of the wells at Green Sulphur Springs and Warford in Summers County. It is not certain, however, that this is the bed which has been so called in all cases, since the Avis, Raines Corner, and Reynolds Limestones are all quite persistent and naturally converge downward toward the top of the Greenbrier or "Big Lime", as the Mauch Chunk Series thins out toward the north. It is believed that the detailed paleontologic and stratigraphic data secured in these three counties will afford a basis for the eventual identification of the "Little Lime" farther north, but in order for this to be accomplished it will be necessary to collect many samples for detailed study from new wells, and the stratigraphic associations must be carefully noted, including the color and physical characteristics.

In its wider relationships the Glenray Limestone may be traced northward across West Virginia into southern Pennsylvania, and southwestward through Virginia to southern Tennessee. Compared with the Mississippi Valley it appears

to be of the same age as the Menard Limestone of Weller[21], as named in Randolph County, Illinois. Such an assumption would be almost a certainty if **Sulcatopinna** should be identified more positively than has been done in the single supposed observation of this fossil in Monroe County. In northern West Virginia this fossil is somewhat abundant in the Lillydale Shale just under the Glenray Limestone, which is a fact of prime importance in this connection.

The Glenray Limestone is usually too impure to be used for agricultural lime, Portland cement, or for other purposes for which a pure lime is demanded, but at some localities in the three counties it would make good material for road or building construction.

The **Nemours Coal** is a lenticular deposit coming within the body of the Glenray Limestone where it breaks up and becomes shaly in the cut of the Norfolk & Western Railway just west of Nemours Station, Mercer County. Here it is a well-defined coal seam, 0′ 3″ thick, occurring in dark shale 27 feet below the top of the limestone, its position being indicated in the Nemours Station Section, page 189, and by **Coal Exposure No. 792 on Map II.**

LILLYDALE SHALE.

The **Lillydale Shale** (new) is a heavy bed of fissile material, dark-green or greenish-gray at top, but black and carbonaceous at the base, with many included lenses of iron carbonate or limestone and with occasional sandstone, the thickness varying from 80 to 125 feet. Marine fossils occur with some abundance in the lenticular streaks of limestone and with much less frequency in the shaly portions, there being numerous brachiopods (especially **Spirifer**), together with pelecypods (**Sulcatopinna** in northern West Virginia), gastropods, and cephalopods. Its position is immediately below the Glenray Limestone and just over the Alderson Limestone member of the Greenbrier Series, making it the basal member of the Bluefield Group of the Mauch Chunk. Beneath it for

[21]Stuart Weller, Mon. Mississippian Brachiopods; Illinois Geol. Survey, p. 28; 1914.

many hundreds of feet the beds are largely of limestone with a minimum of red shale or sandy material, the fossils being brachiopods, corals, and other forms having an affinity for calcareous material. Above and including the shale itself the limestones become impure and shaly and sandy, and red shales appear, together with many pelecypods and other types which flourished in muddy water. In view of these rather abrupt physical and faunal changes the Lillydale Shale becomes the logical beginning of the Mauch Chunk Series.

Its type locality is in Monroe County about four miles southwest of Union in the vicinity of Lillydale where it makes an abundant outcrop along the waters of Back Creek at the southern end of the Knobs Syncline, being continuously exposed along this creek from its head 1½ miles northeast of the village southwestward for two miles to a point one-half mile southwest of Lillydale where the Greenbrier comes above drainage and the shale occurs slightly above the floor of the valley. In this vicinity it is partly dark-green and partly almost coal-black, there being little included ferruginous or siliceous matter. On Indian Draft 1.8 miles above its mouth it is well exposed at elevation 1695′ B., being dark-green and calcareous and having abundant marine fossils among which brachiopods, crinoids, and bryozoa **(Archimedes)** were noted. Farther north it is prominent on a branch of Wolf Creek which enters the creek one mile south of Wolf Creek Post-office, the base of the shale being at elevation 1660′ B., just west of the road fork. In the extreme northwestern corner of the county it is entirely visible along the road between Alderson and Wolf Creek Station at the summit cut of the highway 0.8 mile southwest of Alderson, its base having an elevation of 1745′ B., and its thickness in the low hill just west of the cut being 105 feet. Here it is a greenish-black, fissile shale, with some sandy material toward the top and with lenses of iron carbonate and limestone toward the base. **Fossil Lot 246 on Map IV** was collected across this entire outcrop by Mr. Price and the writer, and probably is as nearly typical as could be found in the three counties, there being numerous brachiopods (especi-

ally **Spirifer**), with pelecypods and a few gastropods, as listed in detail by Dr. Girty in Chapter XVIII.

On the road across the southern end of Flattop Mountain 0.7 mile southeast of Chestnut Grove School it outcrops at a basal elevation of 2600′ B., being partly green and partly black and ferruginous at the base. Around the Swoopes Knobs plateau there is a long outcrop of the shale, a good exposure being visible on the ridge road east of Broad Run School 0.7 mile southwest of Lady Hall School and southward along the road toward Reynolds School its thickness being 90 feet or more, with a greenish color at the top and a black and ferruginous nature toward the base. Just northeast of Reynolds School it is exhibited in the Elmhurst Section, page 222, where it is 95 feet thick and has the above-named characteristics. In the northwestern angle of Bickett Knob, as recorded in the Bickett Knob Section, page 224, it outcrops at elevation 3025′ B. and is 130 feet thick and fissile, being green at the top but turning black and having some thin ferruginous lenses toward the base. On the west slope of the Swoopes Knobs 0.8 mile southeast of Johnson Crossroads it outcrops at elevation 2540′ B., having a dark-green color and being 100 feet thick. It may also be studied on the road from Knobs to Salt Sulphur Springs and on the road from Knobs to Union.

In Summers County the Lillydale Shale is well exposed on Possum Hollow just north of the Greenbrier River as exhibited in the Alderson Section, page 258, where its estimated thickness is 100 feet and its color partly black and partly green. The contact of this shale with the Alderson Limestone of the Greenbrier Series is perfectly exposed at the mouth of Possum Hollow, as is the case at numerous other points in the three counties. In the low hills along the road from Lowell to Creamery 0.7 mile southeast of the former, it makes a good outcrop at elevation 1565′ B., with a greenish-black color and a thickness of about 100 feet. It may also be studied along the Alderson Anticline between Lowell and Riffe at points where the contact is indicated on Map VI. In the Warford Section, page 262, it appears to be represented by 30 feet of red shale in the record of the well drilled at that point; and in the

Green Sulphur Springs Section, page 241, it is 75 feet thick in the record of the well at that place, but no further details are afforded.

In Mercer County the Lillydale Shale first comes above drainage along the Abbs Valley Anticline, being well exposed in the cut of the Norfolk & Western Railway between Nemours Station and Nemours village and slightly west of the former, as exhibited in the Nemours Station Section, page 189. Here there is a visible thickness of 115 feet of the shale, followed below by the Edray Sandstone which belongs within the lower portion of the shale and which forms the outcrop at the western end of the cut, the contact with the underlying Greenbrier Series not being exposed. At this locality the shale is partly sandy and partly dark and fissile, with ferruginous nodules and it contains numerous marine fossils, largely pelecypods, with gastropods and cephalopods. **Fossil Lot 121 on Map II** was collected by Dr. Girty and the writer, the more detailed list of which by the former will be found in Chapter XVIII.

On the Bluefield-Bramwell road 0.4 mile southeast of Pinnacle the shale is again visible near the top of the Abbs Valley Anticline, being green and calcareous with an exposed thickness of 30 feet and having pelecypods, brachiopods, and crinoids. In the Waugh Siding Section, page 192, it is recorded as 120 feet thick, being dark and fissile as exposed along Waugh Siding at the western edge of Bluefield. On the Bluefield-Princeton road about one-half mile southwest of Stony Gap it is again in plain view, being green and fissile at the top, but black toward the base with lenses of iron carbonate, and having a total thickness of 190 feet as recorded in the Stony Gap Section, page 198, and as partly exhibited by Plate XIX. The thickness at this point, however, is excessive and it is probable that it occupies in part the horizon of the Glenray Limestone which appears to be totally absent in the locality of Stony Gap and Bluefield. Farther east in Mercer County it may be noted at many points along the southern base of Stony Ridge and in the gaps of streams tributary to East River, one of its best exposures being at Hales

Gap Tunnel where the Virginian Railway goes beneath a low divide north of Wills Station.

In the edge of Tazewell County, Virginia, it has a visible thickness of 50 feet in the cut of the Virginian Railway just south of Glenlyn village, its nature being dark and sandy, as recorded in the Glenlyn Section, page 203. In the Lurich Section, slightly farther east, its horizon is almost wholly concealed.

The Lillydale Shale appears without much doubt to be the same as the "Pencil Cave", as so called by the oil well drillers of central and northern West Virginia, proof of which is afforded by the fact that the Lillydale Shale may be traced from its type locality northeastward through the Greenbrier Valley to its head and thence northward and northwestward by intermittent exposures in some of the larger anticlines to the most northwestern exposure on the Chestnut Ridge Anticline at Greer, southeast of Morgantown, Monongalia County. Through these various outcrops it gradually decreases in thickness and at some localities becomes distinctly red, but often shows its typical greenish-black, fissile character, which is the case at Greer where it is only five feet thick and where it carries numerous pelecypods (including **Sulcatopinna**), and also brachiopods, and occurs just between the Glenray Limestone of the Mauch Chunk and the Union Limestone of the Greenbrier, the intermediate Alderson Limestone of the Greenbrier having disappeared.

At Hales Gap Tunnel in eastern Mercer County the writer collected a sample (No. 636R) for chemical analysis, and at the same time a very good sample of the "Pencil Cave", coming from the J. K. Long well on Carney Run, Littleton District, Wetzel County, West Virginia, was secured from the Hope Natural Gas Company which drilled this well, the latter sample being labeled 637R for reference purposes. When placed together before grinding these two samples proved to be almost identical both in color and in the peculiar pencil-like weathering from which the shale has secured its name in the oil fields. A comparison of the chemical analyses as made by Mr. Kaplan is as follows:

	Sample 636R, Lillydale Shale at Hales Gap Tunnel.	Sample 637R, Pencil Cave from Long Well.
Silica (SiO_2)	50.94	58.08
Ferric Iron (Fe_2O_3)	6.13	6.02
Alumina (Al_2O_3)	21.25	20.52
Lime (CaO)	3.92	2.16
Magnesia (MgO)	3.39	3.37
Phosphoric Acid (P_2O_5)	trace	trace
Moisture	1.09	2.19
Loss on Ignition	12.73	6.92
Totals	99.45	99.26
Organic Matter	4.68	3.94

Note on Sample 636R: "Some of the calcium and magnesium are combined as carbonates. However, some of the calcium and magnesium are also in the form of silica. It is therefore difficult to estimate how much of the calcium or magnesium is in either form. When treated with acid effervescence occurs. This also applies to 637R."

Note on Sample 637R: "This sample fuses at temperature of the blast lamp, which is approximately 1800 degrees F., while 636R does not."

Outside the limits of West Virginia the Lillydale Shale may be traced into Fayette and Westmoreland Counties, Pennsylvania, and possibly farther. It is plainly visible as far southwestward as Pennington Gap in Virginia, and in Tennessee frequently reappears as far southward as Lookout Mountain near Chattanooga. When compared with the Chester Series of the Mississippi Valley the abundant **Sulcatopinna** which occurs in the Lillydale Shale of northern West Virginia and southern Pennsylvania appears to be quite conclusive evidence that the shale is of the same age as the Menard Limestone of Weller[22], in Randolph County, Illinois, as traced eastward into Kentucky by Mr. Charles Butts and others. In that region **Sulcatopinna missouriensis** is mentioned by Butts as one of the reliable guide fossils of the Menard, and it appears to be almost wholly confined to this and the overlying Clore Formation. It is much to be regretted that **Sulcatopinna** was not discovered earlier in the field studies of the writer so that a more diligent search could have been made

[22]Stuart Weller, Mon. Mississippian Brachiopods; Illinois Geol. Survey, p. 28; 1914.

in southern West Virginia, southwest Virginia, and Tennessee, in order to get more complete evidence on the correlations across the gap of the Cincinnati Anticline.

It is quite possible that the Lillydale Shale may become of much economic importance in the event that the limestones of the Greenbrier Series are utilized in Mercer and Monroe Counties for the manufacture of Portland cement, since it will be the most easily available mixing agent to reduce the lime content of the Greenbrier and to introduce the desirable amount of silica and alumina required for this purpose. It is possible, also, that it could be utilized at some localities for the manufacture of building brick but in general the high content of carbonaceous matter would probably result in too much shrinkage in the kiln, and in localities where there is much calcareous matter its use for such purpose would also be precluded.

EDRAY SANDSTONE.

The **Edray Sandstone** (new) is an important siliceous horizon which in the western part of Mercer County and in Tazewell County, Virginia, and farther northeast in the Greenbrier Valley of West Virginia occurs in the lower part of the Lillydale Shale and when present divides the shale into two parts. In the regions where it is found it is usually a green, flaggy or shaly bed, varying from 10 to 30 feet in thickness, and having its base 10 to 50 feet above the base of the Lillydale Shale, although in some regions it rests directly on the Alderson Limestone of the Greenbrier Series. Its type locality is in Pocahontas County, West Virginia, on the mountain road 1.2 miles north of Edray and only about five miles north of Marlinton. Here it is 25 feet thick, flaggy, and shaly, at elevation 2925′ B., coming 10 feet above the top of the Alderson Limestone member of the Greenbrier, this interval being occupied by green, calcareous Lillydale Shale. Farther west in the same county it is visible at elevation 2780′ B. on the Droop Mountain road about one-half mile northeast of Spice where it is 30 feet thick and comes just over the Alderson member of the Greenbrier.

In Monroe County this sandstone was not observed, but in western Mercer it reappears along the Abbs Valley Anticline in a cut of the Norfolk & Western Railway just west of Nemours Station, where, as recorded in the Nemours Station Section, page 189, it is 25 feet thick. Farther southwest, in Tazewell County, Virginia, it has a thickness of 75 feet in Abbs Valley south of Pocahontas where it makes a distinct ridge in the upturned beds of this group, but in general it is not so prominent, and southwest of this county it seems to disappear.

ECONOMIC ASPECTS, MAUCH CHUNK SERIES.

Considered from an economic standpoint the four groups of the Mauch Chunk Series in Mercer, Monroe, and Summers Counties do not offer much material that can readily be exploited at a large profit. Their coals are too thin to be of commercial value and quite generally too thin and impure even for local domestic use, and they, of course, contain no precious metals of value. As already pointed out in the discussion of the various members certain of the sandstones might be used for building stone but they must compete in most cases with a market that is already quite well supplied. There is a good prospect, however, that the Droop Sandstone of the Bluefield Group can be used for glass-sand. Many of the red shales could also be used for brick or tile manufacture, but such material is of almost universal occurrence and the markets for such products are largely limited to local demand. Some of the limestones may be used for agricultural purposes and as crushed stone for concrete aggregate and road macadam, but they can not compete with those of the Greenbrier and other older series in the uses where pure lime is demanded.

CHAPTER VIII.

STRATIGRAPHY--GREENBRIER SERIES.

GENERAL ACCOUNT AND SECTION, GREENBRIER SERIES.

The Greenbrier Series of the Mississippian is an assemblage of preeminently calcareous rocks, lying just below the Mauch Chunk Series and just above the Maccrady and representing the middle phase of the period. Its name is derived from the Greenbrier River, or perhaps from Greenbrier County, in southern West Virginia, but strangely enough it is not apparent by whom the title was first applied. Weeks[1] ascribes the first use of the term to Dr. I. C. White in 1892 but in the reference therein cited[2] only casual mention of the limestone is made, indicating that the term had been in previous use. Campbell[3] states that the name was first used by W. B. Rogers, but Stevenson[4] says that he himself (Stevenson) first applied the term in 1878 to the whole series (referring to the Mauch Chunk in which the Greenbrier has sometimes been included in Pennsylvania) above the Pocono and says further that Rogers did not use the name until 1883. At an earlier date Rogers had previously used the title "Umbral Limestone", while in Ohio Andrews[5] called it the "Maxville Sandstone" in 1869 but the following year changed it to "Maxville Lime-

[1]F. G. Weeks, North American Geologic Formation Names, Bull. 191, U. S. Geol. Survey, p. 179; 1902.

[2]The Mannington Oil Field and the History of Its Development, Geol. Soc. Am. Bull. Vol. III, p. 190; 1892.

[3]M. R. Campbell, Pocahontas Folio, No. 26; 1896.

[4]Jno. J. Stevenson, American Geologist, Vol. 29, p. 243; 1902.

[5]E. B. Andrews, Ohio Geol. Survey, Report Progress, 1869, pp. 80, 84; 1870.

stone". At an earlier date beds of the same age were studied and named in the Mississippi Valley but these relationships with the formations in the Appalachian region are not yet fully established.

It is quite evident from the statement of Stevenson that his application of the title also included the Mauch Chunk Shale of Ashburner which was named in 1877, as previously noted, page 291, and that this early usage of Stevenson must be delimited from the inclusion of the Mauch Chunk, as has nearly always been done by later authors. Strictly speaking, the Maxville of Andrews is clearly entitled to priority, as Stevenson himself admits in the citation above mentioned, but like many other similar instances the title of Greenbrier has become so firmly fixed in the literature of West Virginia, Pennsylvania, and parts of Virginia that it is now impossible to supplant it by the Ohio title, and, besides, the formation in that State appears to be only a small fragment of the series in West Virginia, there being no fully established correlation between the two.

In the various papers and reports dealing with the Greenbrier it is not apparent that the series has been fully and succinctly defined, either at its type locality in West Virginia or elsewhere, although it has generally been loosely described as a limestone bordered above by the shales of the Mauch Chunk and below by the sandstones of the Pocono or by the shales of the Maccrady in regions where the latter formation exists. In West Virginia its base has never been subject to controversy, since it is clearly distinct from the red and purple shales and yellow, earthy limestones of the Maccrady in the more southern counties, and farther northeast, where these shaly beds disappear, it has an even greater contrast with the underlying sandstones of the Pocono. Farther southwest, however, in Kentucky and Tennessee, the lower calcareous beds of the West Virginia Greenbrier rest upon some of the older Mississippian limestones which are totally absent in West Virginia and probably also in Virginia, and there comprise a sequence in which the differentiation is not so readily apparent.

Ulrich[6], in a diagram, puts the basal part of the Greenbrier of the Allegheny Front region north of the Wytheville Axis opposite the Warsaw of Illinois which is the beginning of his "Tennessean" Series and besides the Warsaw includes the Spergen, St. Louis, St. Genevieve and certain of the Chester formations, but gives no textual discussion of the subject. Girty[7], in a recent discussion of the faunas of the Greenbrier of West Virginia, tentatively concludes that the formation can scarcely be older than St. Genevieve, although admitting that the corals of the basal portion are similar to those of the St. Louis.

In order to secure a more comprehensive view of the relationships of the Greenbrier to the Mississippian limestones of the more southern States the writer made a trip in the season of 1924 to southwestern Virginia, southwestern Kentucky, and across Tennessee to its southern border near Chattanooga. Throughout nearly all of this region the basal (Hillsdale) member of the West Virginia phase of the series may be distinctly traced both by its faunal assemblage and its lithologic character so that it is possible to indicate the position of this bed with respect to the other calcareous Mississippian rocks of those States, and it is expected that the sections then measured will be published in a later volume dealing exclusively with the Mississippian of the Appalachian States, their incorporation in the present Report being impossible because of lack of space. This Hillsdale member appears to correspond almost in its entirety to the St. Louis as described by Butts[8] in the Kentucky Reports and as pointed out on the ground by Mr. Wilbur A. Nelson, State Geologist of Tennessee, at the very good exposures in the Cumberland Mountains in the vicinity of Monteagle, southern Tennessee. Dr. Girty, however, who has studied the numerous collections

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[6]E. O. Ulrich, Revision of the Paleozoic Systems, Bull. Geol. Soc. Am., Vol. 22, Plate 29; 1910. Published in 1911.

[7]Geo. H Girty, Observations on the Faunas of the Greenbrier Limestone and Adjacent Rocks, Tucker County Report, W. Va. Geol. Survey, pp. 450-488; 1923.

[8]Chas. Butts, Mississippian Series in Western Kentucky (1918), and Mississippian Series in Eastern Kentucky (1922); Kentucky Geol. Survey.

of the writer, reiterates (in a letter) his belief that the fauna of the Hillsdale Limestone is of St. Genevieve rather than of St. Louis appearance and will doubtless express his reasons for such opinion in his discussion of the various faunas in Chapter XVIII of this Report. On account of these views which appear to be opposite but which may be eventually brought into accord by a further study of the beds, since the disagreement is wholly amicable, it appears necessary to suggest only a tentative and qualified relationship between the basal beds of the West Virginia Greenbrier and those of the more southern Mississippian.

Whatever may be the final outcome of studies which concern the relationships with the typical localities of Missouri, Illinois, and other States where the Mississippian Rocks were first studied, the West Virginia Greenbrier may now be defined as beginning at the base with the formation which Mr. Butts has classified as the St. Louis in the two Kentucky Reports above cited, herein called the Hillsdale; and as extending upward to and including the Glen Dean Limestone, traced by him to the eastern border of Kentucky at Cumberland Gap, herein designated the Alderson Limestone. In the three counties under study it varies in thickness from 700 feet in northern Summers to 1800 feet in southern Mercer and consists almost entirely of heavy, calcareous beds, nearly all of which are abundantly marine. Sandstones are nearly totally absent, in contrast to their occasional presence farther northeast in West Virginia and farther south and west in other States. There are some lenticular carbonaceous shales and near the middle a thin but persistent stage of red shale, and at two or three horizons there are well-defined plant horizons either in the shales or in the constituent limestones. In the top the beds are somewhat sandy or shaly and impure but slightly farther down they become clean and hard for several hundred feet with a frequently oolitic structure, followed below by more siliceous beds and thin red shales and by other comparatively pure limestones, and finally containing, toward the base, a large amount of black chert bedded in a matrix of dark and somewhat impure limestone. In the whole group

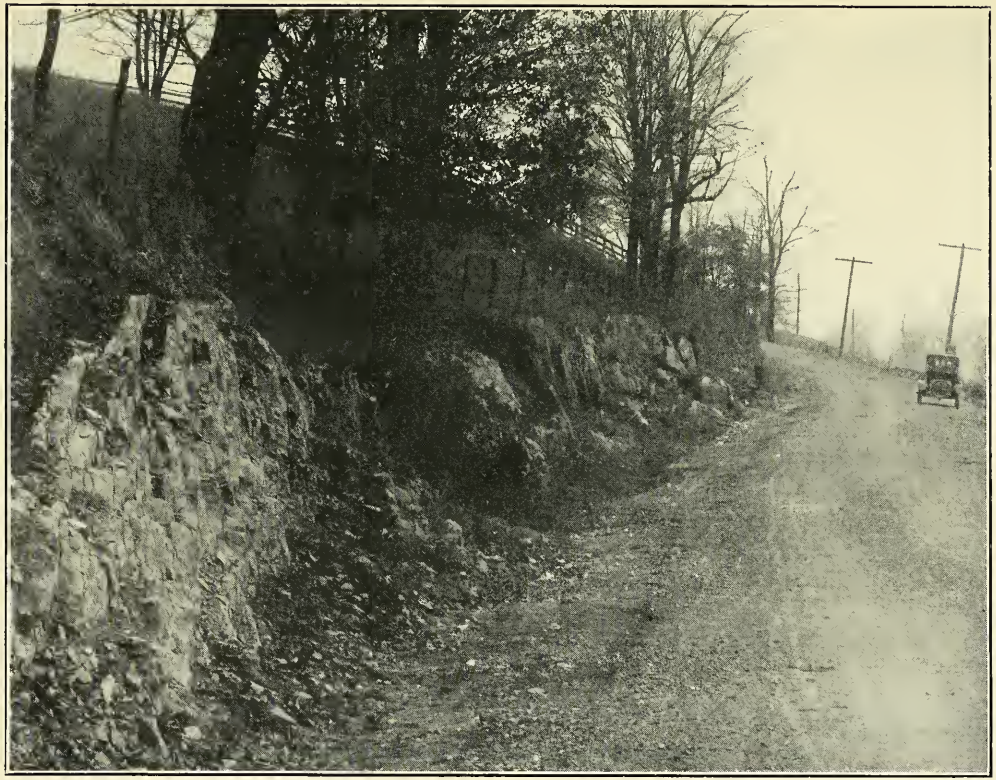


PLATE XXIV.—Looking north along State road one mile north of Union, Monroe County, showing stylolitie Pickaway Limestone which is compressed into vertical columns although true bedding is nearly horizontal but now entirely obliterated. (Photo. by Palmer & Fowler).

there are so many different and contrasting formations that it may no longer be regarded as an indivisible, lithologic entity, as seems to have been the prevalent idea, but it must be considered as an assemblage of beds formed under materially varying conditions. Such being the case it will accordingly be called the **Greenbrier Series** in this Report, since no designation of lower rank will quite fully express its importance in the stratigraphic column.

The following general section, prepared by the writer from many measured sections and local notes, names the various beds of the series and indicates their nature in the three counties and surrounding territory:

General Section of the Greenbrier Series for Mercer, Monroe, and Summers Counties, West Virginia.

	Thickness. Feet.	Total. Feet.
1. **Limestone, Alderson (Glen Dean and Golconda** age), dark-gray, weathering yellow, hard, and somewhat sandy, with a few crystalline streaks; numerous marine fossils, bryozoa (principally **Archimedes** with a few fenestelloids), brachiopods, crinoids (especially **Pterotocrinus**), horn corals and a few pelecypods (see Lots 117, 118, 119, 155, 166, 170, 171, and 247); also plant fossils in chalky beds above middle (see Lots 128 and 233); well exposed on road one-half mile southwest of Alderson, Monroe County, at elevation 1615′ B. and upward to top of plateau; also goes under drainage of Greenbrier River at mouth of Possum Hollow 1½ miles west of Alderson.....	75 to 325	325
2. **Shale, Greenville,** black, fissile, lenticular, with marine fossils, pelecypods (**Caneyella**), cephalopods, and gastropods (see **Lots** 163 and 218); best exposed on Indian Creek road 1.6 miles southeast of Greenville, Monroe County; also visible along Indian Creek road 0.7 mile northwest of Greenville; apparently belongs at the stratigraphic position of the **Cypress Sandstone** of Illinois which is absent in territory of this Report but which reappears at head of Greenbrier River and is present in northern West Virginia.....	100 to 0	325

		Thickness. Feet.	Total. Feet.
3.	**Limestone, Union,** (upper portion **Gasper** age and lower portion **Fredonia** age), gray, weathering white, hard, often crystalline, and usually pure; often oolitic; contains numerous marine fossils, blastoids (abundant **Pentremites**), crinoids, brachiopods, horn corals, a few gastropods, and bryozoa (**Archimedes**) (see Lots 116, 127, 151, 172, 173, 295, and 298); makes prominent exposure along roads and sinks just southwest and northwest of Union, Monroe County; farther northeast in West Virginia and in southwest Virginia a sandstone (**Rosiclaire Sandstone?**) intervenes between the Gasper and Fredonia portions but was nowhere observed in the territory of this Report.....	100 to 275	600
4.	**Limestone, Pickaway,** very dark, hard, and sandy, styolitic through most of Monroe County; contains scanty marine fossils, brachiopods, gastropods, bryozoa, blastoids, and crinoids (see Lots 114, 115, 145, and 174); outcrops along highway between Union and Pickaway, Monroe County, with quarries at several points.....	175 to 400	1000
5.	**Shale, Upper Taggard,** red.....	10 to 15	1015
6.	**Limestone, Taggard,** white, medium-soft, pure; contains scanty marine fossils, brachiopods, crinoids, bryozoa, and blastoids (**Pentremites**) (see Lots 150, 152, 175, and 256); nearly always oolitic; visible in road just north of Taggard Branch 2.7 miles southward from Union and 1.6 miles northeast of Willow Bend, Monroe County	5 to 15	1030
7.	**Shale, Lower Taggard,** red or sandy.....	10 to 20	1050
8.	**Limestone, Patton,** shaly and sandy at top; blue, hard, and pure, weathering gray, toward base, with occasional nodules of black chert; contains scattered marine fossils, brachiopods, crinoids, horn corals, bryozoa, and blastoids (**Pentremites**) (see Lots 113 146, 176, and 177; also contains a plant fossil zone in middle portion (see Lot 232); visible in bluff of Second Creek starting at elevation 1950′ B. on private road one-third mile southeast of Patton, Monroe County, extending upward to top of plateau; also well exposed on road from Sinks Grove to Bickett Knob between elevations 2265 and 2475′ B.	100 to 250	1300
9.	**Shale, Patton,** gray and highly calcareous; contains abundant plant fossils (see Lots 228 and 231); also carries marine fossils, brachiopods, blastoids (**Pentremites**), and bryozoa (see Lot 147); named from associa-		

		Thickness. Feet.	Total. Feet.
	tion with Patton Limestone but best exposed in road 0.8 mile southeast of Pickaway, Monroe County; also visible in the narrows of New River, Giles County, Virginia	10 to 20	1320
10.	**Limestone, Sinks Grove**, blue, hard, somewhat sandy and impure throughout; weathers yellow at top but gray in lower portion; contains great amount of black, nodular, carbonaceous chert which weathers gray on long exposure; also contains marine fossils both in matrix and in chert, brachiopods (**Productus** and **Orthotetes**), bryozoa, crinoids, horn corals, and blastoids (**Pentremites**) (see Lots 108, 111, 112, 130, 148, 178, and 179); is prominent in vicinity of Sinks Grove, Monroe County	175 to 330	1650
11.	**Limestone, Hillsdale** (apparently the equivalent of **St. Louis Limestone** as described by Butts in Kentucky and Tennessee), blue and hard at top, with streaks of sandy shale toward base; calcareous portions contain abundant black, nodular chert, weathering to gray; sparingly fossiliferous in chert, but very numerous in matrix, corals (especially **Lithostrotion**), brachiopods (including **Productus** and **Orthotetes**), bryozoa (including fenestelloids), crinoids, and gastropods (see Lots 111, 140, 144, 149, and 153); visible in road just east of Hillsdale, Monroe County	50 to 150	1800
Maccrady Series		.. ...	....

SUBDIVISIONS, GREENBRIER SERIES.

In the above general section, which is the first of its kind to be published of this series in any West Virginia Report, these rocks have been subdivided into members according to the lithologic and faunal peculiarities that prevail in southern West Virginia, but as might naturally be expected and as will be more fully discussed under the subject of "Correlation", these minor stages do not correspond in their entirety to other subdivisions which have previously been made in the distant States of the Mississippi Valley where they were first exhaustively studied, but there are many points of similarity and in some cases the age equivalents can be safely noted. In the middle portion of the series, however, embracing all the beds from the top of the Pickaway Limestone down to the base of

the Sinks Grove Limestone and totalling 1050 feet of strata at some localities, these beds have representation only in southern West Virginia and southwest Virginia, being wholly absent in other States of the Appalachian region and almost, if not wholly, gone from the column in the Mississippi Valley itself. These sediments fill the hiatus postulated by Butts[9] as occurring between the St. Genevieve and St. Louis Limestones but described at the same time as being occasionally occupied by a thin-bedded, non-oolitic limestone containing an abundance of **Platycrinus huntsvillae.** It is believed that the discovery of this great mass of intermediate beds may do much toward the removal of many uncertainties which have previously interfered with the correlation of the beds on either side of the Cincinnati Anticline.

On paleontological evidence it would doubtless be possible to separate the Gasper and Fredonia portions of the Union Limestone, but in the three counties under study there is no other means by which a division could be made, since both portions are frequently oolitic and both are of the same general texture and appearance and the sandstone, which separates them in regions farther southwest as well as farther north in West Virginia, is totally absent. Under such circumstances it has seemed best to describe this stage as a local physical unit, leaving its more minute organic study as a special problem for the future. In this, as well as in most other subdivisions of the series, the boundaries have been drawn at horizons where some physical change attracts the eye, there being in most cases a corresponding change in the faunal assemblages. These physical and faunal differences, used in conjunction, are so truly remarkable that when once mastered by a trained observer they may be readily followed throughout the Appalachian outcrops, or through the geographic range of each formation as the case may be, there being some localities where appearances become abnormal only to be followed elsewhere by the standard types.

[9]Chas. Butts, Mississippian Series of Eastern Kentucky, Ky. Geol. Survey, pp. 129-136; 1922.

TOPOGRAPHIC EXPRESSION, GREENBRIER SERIES.

In Mercer County the Greenbrier outcrop is almost wholly confined to a narrow strip in the valleys of Bluestone and East Rivers where the strata have been overturned and now stand at a sharp angle so that only the edges of the beds are exposed. In this region the only noticeable topographic effect is that the drainage of these two major streams has in general followed the limestone outcrop, there being a few exceptions, one of which is Spangler Valley where East River leaves the calcareous beds and some sink-holes have developed. Along the Abbs Valley Anticline in the vicinity of Nemours, the Greenbrier forms the surface outcrop for several miles, being compressed into a rather sharp but not overturned fold. In this region its effect may be noted in some slight depressions and in the less rugged nature of the hills, but just southwestward in Tazewell County, Virginia, where more of the limestone is exposed there is a deep valley with subterranean drainage.

In Monroe County there is a long strip of the Greenbrier crossing the southwestern part of the county south of the Hurricane Ridge Syncline and being a continuation of the overturned beds previously mentioned in Mercer. Just southwest of Union, however, the beds regain their normal position and extend across the axis of this basin so that there is a broad expanse of country covered by this series without much extraneous influence. Here the ground is mainly a plateau elevated several hundred feet above the level of Greenbrier River and its major tributaries, and throughout a very considerable part of this region the streams have become subterranean and there are numerous deep sink-holes some of which have become clogged with mud until they pond the surface water, the whole effect being that of a typical "karst" topography. In certain sections the more resistant beds of limestone stand out in reefs and make the low ridges and toward the western part of the region the sandstones of the lower part of the Mauch Chunk Series form table-lands or mountains not yet eroded down to the level of the Harrisburg Peneplain which

forms the surface of the plateau around Union. In the region west of Swoopes Knobs the streams have generally cut their channels to a much deeper level so that sink-holes and intermittent drainage are much less common.

In Summers County the Greenbrier Series outcrops only along Greenbrier River and a few intermediate tributaries southwest of Alderson, its influence on the topography being negligible.

AREAL EXTENT, GREENBRIER SERIES.

Figures 12, 13, and 14 prepared by Mr. Price, respectively indicate the outcrops of the Greenbrier Series in Mercer, Monroe, and Summers Counties; and Maps II, IV, and VI show the same outcrops in much greater detail. By these maps and figures it is evident that the Greenbrier makes only a small percentage of the surface of Mercer and only a small fraction of that of Summers, but that in Monroe County it comprises perhaps 20 per cent. of the outcropping strata. In Mercer the series is confined to a narrow wedge along the Abbs Valley Anticline next to Virginia, and to a narrow belt crossing the southern part of the county approximately with the line of the Norfolk & Western Railway from Graham (now Bluefield, Virginia), to the neighborhood of Glenlyn, about 22 miles long and usually less than half a mile wide.

In Monroe County the same belt of overturned Greenbrier which crosses Mercer extends northeastward about 15 miles, and then regaining its normal bedding, widens out and turns northward toward Greenbrier County, covering an almost continuous area fifteen miles long and six or eight miles wide. East of this region the upper portion of the series is exposed along the Pedro Syncline on Cove Creek, while on the west there is a considerable area from Alderson southward, having a narrow connection with the large central region, and another independent outcrop along the Abbs Valley Anticline in the vicinity of Greenville.

In Summers County the series outcrops only along or near Greenbrier River close to the axis of the Alderson Anti-

cline in the eastern edge of the county next to the Monroe and Greenbrier lines, there being scarcely more than 100 feet of it above drainage.

The full series may be studied along the upturned beds in southern Mercer County from Bluefield eastward and at most points along this outcrop there is no truncation of the beds at the base, in spite of the long prevalent belief that such is the case. These exposures were fully measured at the Stony Gap Section, page 198, and at the Lurich Section, page 204, the latter locality being in the edge of Giles County, Virginia, but in general the beds are somewhat difficult to follow in consecutive fashion owing to the crooked courses of the minor streams along which they may be traced. In Monroe County a much better opportunity is afforded to study the series, although it is not quite so thick as in Mercer. At the Bickett Knob Section, pages 224-5, the entire thickness is exposed in beds which lie approximately horizontal, there being no better locality for the observation and study of this series in the entire Appalachian region. In the absence of any previous specific designation this exposure may well be considered as the type locality.

FIGURE 12.
MAP
OF
MERCER CO.
SHOWING
OUTCROPS OF
PURE LIMESTONE.
Scale 1 inch = 8 miles
RALEIGH CO.
SUMMERS COUNTY
JUMPING BRANCH
ROCK
PLYMOUTH
ATHENS
PRINCETON
EAST RIVER
BEAVERPOND
MONROE CO.
McDOWELL CO.
WYOMING CO.
VIRGINIA
TAZEWELL COUNTY
BLUEFIELD
BLAND COUNTY
GILES COUNTY
VIRGINIA
GREENBRIER
STONES RIVER
(Chickamauga)
PHPrice

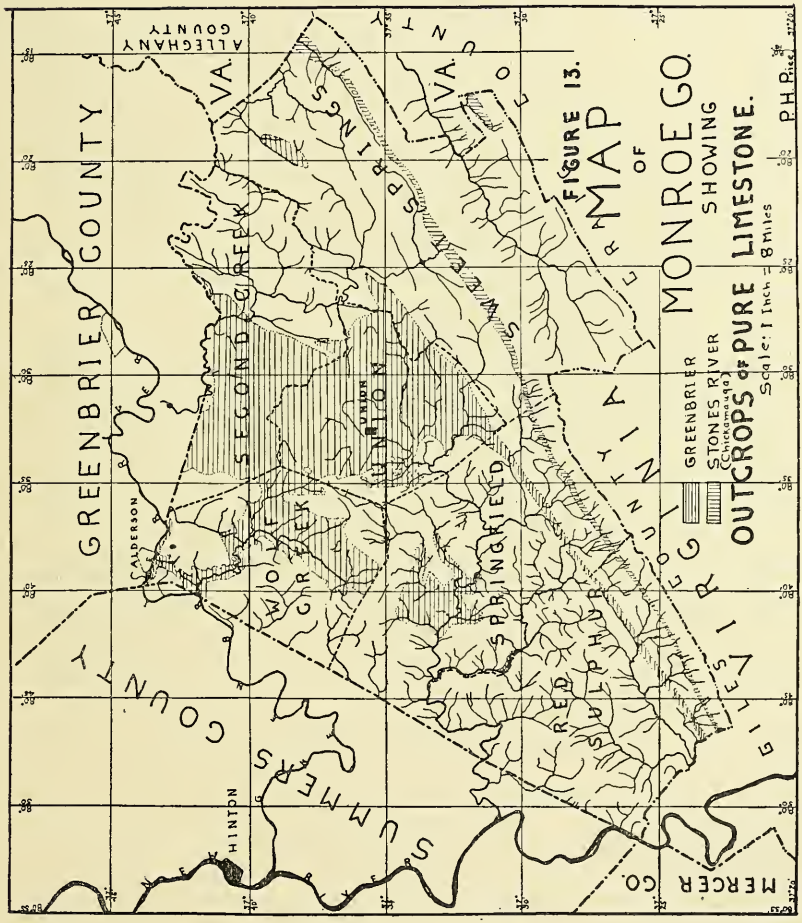
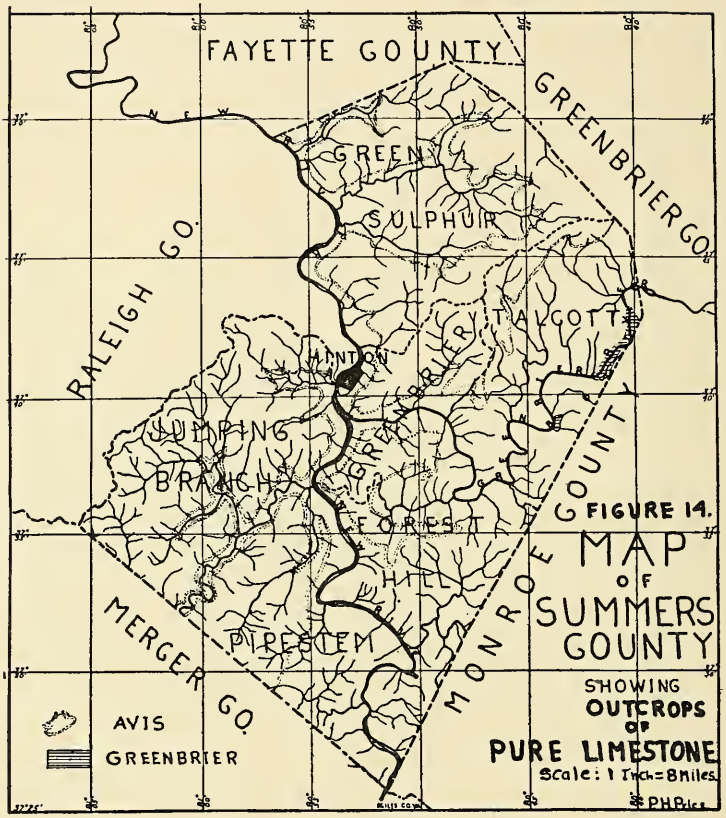


FIGURE 13. MAP OF SHOWING



CONTACTS, GREENBRIER SERIES.

The contact of the Greenbrier Series with that of the overlying Mauch Chunk has already been discussed under the description of the latter series in Chapter VIII, pages 308-9, the more shaly character of the Mauch Chunk limestones and the presence of distinct beds of shale, some of which are red, being noted, as well as the occurrence of abundant pelecypods which are rare in the Greenbrier.

At the base of the Greenbrier its contact with the underlying Maccrady Series is much more marked, both in lithologic aspect and in organic life. In the Maccrady the strata

are largely red or purplish shales or weakly bedded sandstones, all largely devoid of marine fossils, there being occasional yellow and earthy limestones in the upper part which carry infrequent fauna. From the purely local view in Mercer and Monroe Counties this contact might be considered as representing an unconformity of some magnitude. This may indeed be the case but it will hardly be susceptible of proof until the age of the Maccrady has been more definitely determined. There is no doubt, however, that in these two counties 300 feet or more of beds belonging in the upper portion of the Maccrady are missing, since the reddish portion of the series at the type locality near Maccrady and Saltville, Virginia, is separated from the Greenbrier by approximately that amount of sandy or calcareous beds in which there are abundant fenestelloids and many brachiopods. In a discussion which has bearing on the question of a more important unconformity at this stage, Dr. Girty[10] surmises that the Maccrady may be of Warsaw age, although he states that the evidence is quite unsubstantial. If such should indeed prove to be the case and if the Hillsdale Limestone, forming the basal member of the Greenbrier in Monroe County, proves to be the same as the St. Louis, which the work of Butts and the writer appears to indicate but which Dr. Girty does not yet admit, it is then apparent that the unconformity between the Greenbrier and Maccrady is mostly caused by the absence of the Spergen Limestone of Indiana, if no regard be paid to a possible time break in which no deposition occurred.

FOSSIL LIFE, GREENBRIER SERIES.

In the three counties there are abundant remains of marine invertebrate life in the Greenbrier Series, there being fossils in all of the subdivisions of the general section except the Upper and Lower Taggard Shales which are generally red. Numerous collections of these fossils were made in the field

[10]Geo. H. Girty, Observations on the Faunas of the Greenbrier Limestone and Adjacent Rocks, Tucker County Report, W. Va. Geol. Survey, pp. 482-483; 1923.

by the writer, with some help also from Dr. George H. Girty of the United States Geological Survey, and with a little further assistance from Dr. Prouty and Mr. Price of the West Virginia Survey Staff. Dr. Girty has kindly undertaken the study of all these collections and his lists and discussions will be found in Chapter XVIII. A list of all collection localities is published in Chapter XVII.

Plant remains were discovered in the Greenbrier at two horizons that are somewhat persistent and also at a third the continuity of which is still somewhat in doubt. These very interesting occurrences in the midst of a marine limestone series were given some study in the field by Dr. David White of the United States Geological Survey whose discussion will be found in Chapter XVII.

No vertebrate remains of any description were observed in the series in any of the three counties.

CORRELATION, GREENBRIER SERIES.

In the general section at the beginning of this Chapter the relationships of some of the members of the Greenbrier Series of southern West Virginia to the earlier described subdivisions of the Mississippi Valley have been parenthetically indicated. These age assignments represent mainly the views of the writer after tracing the beds southwestward across Virginia into Kentucky and Tennessee where a connection is effected with the studies of Butts who has described these rocks in the two volumes of the Kentucky Survey on the Mississippian of the eastern and western portions of that State as previously cited. Dr. Girty, who now has the fossils under study, has agreed that certain of these correlations may be applied in a tentative sense and previous to the work of the writer had already suggested (in the citation of foot-note No. 10) the identity of certain of the West Virginia Greenbrier beds with those of the St. Genevieve of Missouri, but he has not yet agreed that the Hillsdale Limestone corresponds to the St. Louis. Inasmuch as the writer has not visited the type locality of the St. Louis nor inspected it at any locality west of the

Cincinnati Anticline he can not now go further than to indicate his conclusion that the Hillsdale is the same as the beds which have been named as St. Louis by Butts in Kentucky and the same as those which have been pointed out as St. Louis by Nelson in Tennessee.

It is evident from the general section that the upper members, including the Alderson Limestone, Greenville Shale, and the upper portion of the Union Limestone, are part of the Chester Series of Illinois and that the somewhat prevalent idea that the base of the Mauch Chunk Series corresponded roughly to the base of the Chester must be abandoned, since the lower portion of the Chester reaches down into the very heart of the Greenbrier and may indeed include all of the Union Limestone, depending on what authority may be accepted as final on the much disputed contact of the Chester and Meramec of the west.

At the base of the Greenbrier it is also evident that the series does not include some of the older calcareous rocks of the west and south which intervene between the base of the St. Louis and the top of the siliceous beds variously described as Cuyahoga, Logan, New Providence, etc. If the Hillsdale be eventually accepted as the St. Louis, and if the Maccrady should prove to be the same as the Warsaw, which latter correlation Dr. Girty suggests with much misgiving and which the writer looks upon with even less confidence after examining the supposed Warsaw in Kentucky and Tennessee, there remain unaccounted for the Spergen Limestone of Indiana and nearly all of the Osage Series, including the Fort Payne Chert which is an important and persistent formation in the southern Appalachian States. There is certainly no Fort Payne in southern West Virginia and no Spergen, or Bedford Oolite, as it is often commercially termed.

It is hardly in order to discuss under this heading the beds of the Mississippi Valley which are older than the Osage, since they have not been connected with the West Virginia Greenbrier by any sort of implication.

In the general section of the Greenbrier no correlation of any kind is suggested for the 1050 feet of beds lying between the Union and Hillsdale Limestones and apparenty none can be possible since these rocks are almost wholly confined to southern West Virginia and the adjoining portion of southwest Virginia. They do not occur at all in the eastern half of Tennessee, and in Kentucky, Butts mentions only about 50 feet of sediments at one point between the St. Genevieve and St. Louis. In Washington County, Virginia, where they reach their maximum, the writer measured 1865 feet of these new and previously undescribed beds.

It is now apparent that the West Virginia Greenbrier has a complexity that is far beyond any of its previously suspected affiliations, both in the way of new beds and in its relationships to the known rocks of other regions. New beds peculiar to the two Virginias comprise nearly two-thirds of its mass. Its upper portion belongs with the Chester of Illinois and the St. Genevieve of Missouri (if all the latter be not included in the Chester), while its lower (Hillsdale) member, which is separated from the Chester and St. Genevieve portions by the new beds, must either be classed as the St. Louis Limestone or else the St. Genevieve must be considered as having expanded into a formation many times its known limits in the Mississippi Valley. In a future volume it is hoped to discuss this series more fully and to present the numerous extra-territorial sections on which conclusions have been based.

DESCRIPTION OF MEMBERS, GREENBRIER SERIES.

ALDERSON LIMESTONE.

The **Alderson Limestone** (new), coming just below the black, Lillydale Shale of the Mauch Chunk and being the upper member of the Greenbrier Series, is quite generally a dark-gray calcareous formation, weathering almost to a dirty yellow color, with a thickness which varies from 75 to 325 feet, and having an abundance of marine fossils. Its bedding from top to bottom is not uniform, there being some zones

which contain an excess of silica making a very hard and durable limestone, and others which are composed of fairly pure and highly crystalline limestone, while still others contain muddy material and readily disintegrate into shaly blocks with a calcareous cleavage or fracture. This somewhat complex stage of strata is definitely bounded above by the dark shale of the basal Mauch Chunk and quite distinctly marked below by the pure grayish-white Union Limestone, and is further marked by its faunal assemblage which is not elsewhere duplicated in the Greenbrier, although it is doubtful if any individual fossil may be regarded as diagnostic. It quite generally contains numerous brachiopods and there are occasional horn corals and pelecypods, but its most noticeable fossil is **Pterotocrinus,** the plates of which often outlast the matrix and stand out in white relief giving the stone much the appearance of a conglomerate. It also carries many bryozoa, the most common and easily recognized of which is **Archimedes,** there being frequent fenestelloids. It is further distinguished by a plant fossil zone coming in chalky beds slightly above the middle of the member and being quite abundant when found but of somewhat infrequent occurrence.

Its type locality is in the northwestern corner of Monroe County in the vicinity of Alderson, one of its best exposures being on the road toward Wolf Creek one-third mile south of Alderson, its base being at elevation 1615′ B. and its thickness 95 feet, with the same general characteristics as above described except that no plant fossils were noted. Here Mr. Price and the writer collected **Fossil Lot 247 on Map IV,** there being bryozoa, including **Archimedes,** many brachiopods, and a few pelecypods, as more fully listed by Dr. Girty in Chapter XVIII.

This exposure of the Alderson Limestone passes under drainage on Greenbrier River at the mouth of Possum Hollow 1½ miles west of Alderson in Summers County near the common corner with Monroe and Greenbrier but along the axis of the Alderson Anticline it extends southwestward into Summers again, being exposed near Wolf Creek Station and southwestward to Riffe and outcropping on Kelly Creek southeast

of Pence Springs and on Wind Creek southeast of Lowell. Throughout Monroe County this member may be studied at almost any point where the Mauch Chunk-Greenbrier contact is delineated on Map IV. In the northern end of Bickett Knob, as recorded in the Bickett Knob Section, page 224, it is 130 feet thick, and contains many marine fossils among which are brachiopods, crinoids, horn corals, and bryozoa, including **Archimedes,** and fenestelloids. Here the writer collected **Fossil Lots 170 and 171 on Map IV,** the more complete list of which by Dr. Girty will be found in Chapter XVIII. In the Elmhurst Section, page 222, it occupies an interval of about 165 feet, being dark or shaly with marine fossils. On Indian Draft it is visible at elevation 1645′ B. along the road 1.2 miles south of Wayside, having many fossils including crinoids, brachiopods, and bryozoa **(Archimedes).** Here **Fossil Lot 166 on Map IV** was collected by the writer, the full list of which by Dr. Girty will be found in Chapter XVIII.

At the **Lewis McNeer Quarry** on the south side of Indian Creek opposite Gin Hollow and near Salt Sulphur Springs, 50 to 60 feet of the limestone is visible, being blue and shaly and containing crinoids, brachiopods, pelecypods, and bryozoa. Here **Fossil Lot 155 on Map IV** was collected by the writer, the more detailed list of which by Dr. Girty is published in Chapter XVIII. Plate XXI shows a view of this quarry.

In the edge of Giles County, Virginia, it is only partly exposed in the cut of the Norfolk & Western Railway on the west side of New River one-third mile southwest of Rich Creek Station, but as recorded in the Lurich Section, page 204, it contains a plant fossil zone approximately 155 feet below the top, from which **Fossil Lot 233 on Map II** was collected by Dr. David White, Mr. Price, and the writer, the discussion of which by Dr. White will be found in Chapter XVII.

In Mercer County there are numerous exposures of the Alderson Limestone along East River just south of the Mauch Chunk-Greenbrier contact as indicated on Map II. Just southwest of Hales Gap Tunnel it is visible between the Virginian and Norfolk & Western Railways, as will be later described under the subject of "Limestone" in Chapter XIV. Along the

PLATE XXV.—View from Red Mill, Monroe County, looking northeast across Second Creek. Smooth ground in valley is Maccrady. Wooded slope of Middle Mountain at right is Pocono. Elk Knob in right rear and ridges farther to left are Chemung. (Photo. by Palmer & Fowler).

Bluefield-Princeton road about one-half mile southwest of Stony Gap it is 333 feet thick, as recorded in the Stony Gap Section, page 198, and as partly exhibited by Plate XIX. At this point it contains an abundant plant fossil zone about 100 feet below the top, from which **Fossil Lot 128 on Map II** was collected by Dr. David White, Mr. Price, and the writer, the report on which by Dr. White will be found in Chapter XVII. The writer also collected **Fossil Lot 119 on Map II** in the upper 110 feet of the formation, **Fossil Lot 118 on Map II** in the middle 67 feet, and **Fossil Lot 117 on Map II** in the lower 156 feet, there being many brachiopods and crinoids and also horn corals and bryozoa (including **Archimedes**), as listed in full by Dr. Girty in Chapter XVIII.

In the western edge of Bluefield it is recorded in the Waugh Siding Section, page 192, as 175 feet thick, but it is poorly exposed and the visible beds may not represent the full thickness. On the Abbs Valley Anticline it may be noted on either side of Bluestone River at Nemours village, there being **Archimedes** and horn corals at the southern end of the foot-bridge across the river. Farther northeast along the descending axis of this anticline the limestone is visible in the public road on Sandlick Creek 0.7 mile northwest of Sandlick as exhibited by Plate XX, but the full thickness of the member is not above the surface.

When traced southwestward into Virginia, Kentucky, and Tennessee, the Alderson Limestone quite clearly corresponds to the Glen Dean Limestone and also appears to include the horizon of the Golconda Shale which seems to become more calcareous in a northeastern direction so that it is not readily distinguished from the Glen Dean. Northeastward across West Virginia the Alderson may be traced as far as Tucker County but in Preston County at Rowlesburg it is only ten feet thick and along the Chestnut Ridge Anticline in Monongalia County, West Virginia, and along the same arch in Fayette and Westmoreland Counties, Pennsylvania, it has completely disappeared.

The Alderson member does not appear to be suited for purposes where a high-grade limestone is required and it usu-

ally contains shale beds which make it of doubtful value for construction material. A further discussion of quarries and a chemical analysis will be found under the subject of "Limestone" in Chapter XIV.

GREENVILLE SHALE.

The **Greenville Shale** (new) is a black, fissile, and carbonaceous deposit belonging, when present, between the Alderson and Union Limestones but being quite lenticular and largely confined to a portion of Monroe County where it sometimes reaches a thickness of 100 feet, and containing marine fossils among which there are pelecypods **(Caneyella)**, cephalopods, and gastropods. Its type locality is in Monroe County in the road on the north side of Indian Creek 0.1 mile northwest of Hunter Spring School and 1.6 miles southeast of Greenville Here it is sandwiched between the Alderson and Union Limestones, having a visible thickness of about 100 feet and dipping sharply southeastward and containing marine fossils which at first glance are highly suggestive of the Upper Carboniferous on account of the **Naiadites** and **Orbiculoidea** that it contains, but this is only a resemblance since it also holds **Caneyella, Orthoceras,** and other forms more in keeping with its Mississippian age. **Fossil Lot 218 on Map IV** was collected here by Dr. Girty and the writer, as listed in detail by the former in Chapter XVIII. On the west limb of the Abbs Valley Anticline the shale is again exposed in the road north of Indian Creek and 0.7 mile northwest of Greenville, having a visible thickness of 50 feet and containing marine fossils among which were noted gastropods, pelecypods (including **Naiadites**), and brachiopods **(Lingula)**. At this point **Fossil Lot 163 on Map IV** was collected by the writer, the report on which by Dr. Girty will be found in Chapter XVIII. On Laurel Creek it makes an outcrop about three-fourths mile in length starting 0.2 mile west of Buckeye School and gradually descending eastward until it passes beneath the creek on the east limb of the Abbs Valley Anticline. On Cooks Run of Indian Creek one mile south of

Greenville it is again exposed along the same anticline, being about 100 feet thick and having a dark-green color. On the south end of Swoopes Knobs it is exposed at elevation 2240′ B. along the road from Knobs to Salt Sulphur Springs, being black, calcareous, and 55 feet thick. Farther east it descends rapidly toward the Hurricane Ridge Syncline and is prominent along the Indian Creek road slightly east of Gin Hollow, its thickness being from 50 to 75 feet and mostly made up of black shale. It is also visible on the east side of Swoopes Knobs along the Knobs-Union road at elevation 2560′ B. and is there about 100 feet thick but has become somewhat calcareous.

At the southern edge of Alderson this shale outcrops at elevation 1560′ B. at the foot of the mountain road which goes toward Mt. Pleasant School, its visible thickness being about 60 feet and its color black and green. Farther south it is again well exposed on the road from Wolf Creek Station to Alderson, being visible at the road fork one-third mile east of the former point, with a thickness of 75 feet, its top being at elevation 1615′ B., and its base not being exposed. Here it is a dark and sandy shale. Farther up Wolf Creek toward Jarrett School and Trinity Church it may be observed at various points.

Beyond the limits of Monroe County this very interesting black shale was not observed and so far as known it does not occur in other States. Its stratigraphic position is apparently much the same as that of the Cypress Sandstone of Illinois but this sandstone does not occur in the three counties, although it is plainly visible northeastward in West Virginia. The Greenville Shale, however, is so entirely different from the sandstone that it can hardly be assumed as representing the Cypress and the relationships of the two are not clear, since they were never observed in the same locality.

UNION LIMESTONE.

The **Union Limestone** (new), belonging just under the Greenville Shale when that lenticular bed is present, but more generally just under the Alderson Limestone and from 100 to

325 feet below the top of the Greenbrier Series, depending on the northwestward thinning of the strata in the three counties, is a gray, hard limestone weathering white and being often crystalline, usually pure, having frequently an oolitic structure and containing numerous marine fossils, its thickness varying from 100 to 275 feet. In the upper part its fauna contains many blastoids **(Pentremites),** and a few bryozoa (including **Archimedes),** and in the lower half **Platycrinus huntsvillae** may be recognized, and throughout the whole formation there are brachiopods, horn corals, a few gastropods, and many miscellaneous crinoids. Its type locality is in Monroe County at Union where the dip of the rocks is westward toward the Hurricane Ridge Syncline, the base of the Union Limestone being in the western edge of town, from which the member extends westward and forms the surface rocks on either side of the syncline and contains deep sink-holes along the now submerged valley of Indian Creek.

In the three counties under study it is apparently a continuous lithologic unit from top to bottom, but farther northeast in West Virginia it is sometimes separated into two benches by a lenticular sandstone, and farther southwest in Virginia this sandstone again occurs. Its total absence in southern West Virginia makes it quite impossible to divide the formation except by laborious paleontologic study. It may be traced southwestward into Kentucky and Tennessee where there is little doubt that its upper portion represents the Gasper Oolite of western Kentucky; while its lower portion corresponds with the Fredonia Oolite of Indiana, and is therefore a part of the St. Genevieve Formation of Missouri as is made almost certain by the presence of **Platycrinus huntsvillae** in Mercer County. Northeastward it can be traced to the Pennsylvania State line where its upper portion remains pure and oolitic while the lower part becomes quite siliceous and almost barren of fossils, the two benches being separated by a lenticular sandstone which may correspond to the Rosiclaire Sandstone of Illinois. This aspect of the series continues into Fayette and Westmoreland Counties, Pennsylvania, and may also be noted as far northeastward as Hunting-

don County. Inasmuch as the lower portion may be traced westward until it coincides with the Fredonia Oolite and may be followed northward until it becomes sandy and dovetails into the Siliceous Limestone of Stevenson, later called Loyalhanna by the United States Geological Survey, in Pennsylvania, it follows that a correlation between these two far distant exposures appears to be effected. The Gasper portion of the Union Limestone also extends into Pennsylvania in approximately the same territory as occupied by the Fredonia portion, making an additional correlation throughout several hundred miles of the Appalachian region. The Union Limestone thus appears to be the most persistent member of the Greenbrier Series in the territory east of the Cincinnati Anticline since it reaches from Pennsylvania to Alabama.

In Monroe County **Fossil Lot 151 on Map IV** was collected by the writer at the type locality, starting in the State road at the high school at the southwestern edge of Union and following this road southwestward for about one-fourth mile, being mostly in the Gasper portion. Here it contains abundant blastoids **(Pentremites)**, many brachiopods, numerous crinoids, and also bryozoa (including **Archimedes)** as more fully detailed by Dr. Girty in Chapter XVIII. **Fossil Lot 298 on Map IV** was later collected by the writer starting in the sinks west of the Hurricane Ridge Syncline one-half mile northwest of Union and following the outcrop one-half mile southward through the sinks and across the syncline to the road fork one-half mile southwest of Union. This latter collection reaches down to the base of the Union Limestone and was therefore made mostly in the Fredonia portion, its fossils being listed in Chapter XVIII by Dr. Girty. Farther south the limestone continues to be well exposed along the Indian Creek road nearly to the mouth of Burnside Branch. On the road from Union to Knobs it is again visible at elevation 2340′ B., having a thickness of 170 feet and containing a fauna similar to that at Union. On the south end of Swoopes Knobs it is visible along the Knobs-Salt Sulphur Springs road at elevation 2025′ B., having a thickness of 190 feet. On Turkey Creek it is well exposed about one mile southeast of the Hurri-

cane Ridge Syncline and there contains brachiopods, bryozoa (**Archimedes**), blastoids (**Pentremites**), and horn corals. West of the Hurricane Ridge Syncline on Indian Creek it is above drainage both east and west of the mouth of Back Creek and farther west it may be studied on Cooks Run southeast of the Abbs Valley Anticline and on Indian Creek just west of Greenville, while on Laurel Creek north of Greenville it outcrops slightly southwest of Buckeye School and there appears to be the formation through which Laurel Creek passes into its subterranean flow of more than a mile. Farther north it is prominently exposed west of Johnson Crossroads, and on the west slope of Swoopes Knobs it is recorded in the Elmhurst Section, page 222, as 200 feet thick, being gray, massive, and pure, at elevation 2325′ B. On Broad Run of Wolf Creek it outcrops near the road fork 1.7 miles southeast of Wolf Creek Post-Office, and also farther east on the road toward Sinks Grove where the structure rises approximately with the topography.

At the north end of Swoopes Knobs it is fully exposed along the hill road north of Bickett Knob, being 155 feet thick, as recorded in the Bickett Knob Section, page 224. Here **Fossil Lot 172 on Map IV** was collected by the writer from the upper 25 feet and entirely in the Gasper portion, there being blastoids (**Pentremites**), crinoids, bryozoa (including **Archimedes**), and horn corals. **Fossil Lot 173 on Map IV** was collected by the writer from the lower 125 feet of the formation, including the Fredonia portion and probably part of the Gasper, the fauna being much the same as above noted. The detailed list of both collections, as studied by Dr. Girty, will be found in Chapter XVIII.

On the southern end of Flattop Mountain the top of this formation is visible at elevation 2490′ B. three-fourths mile northwest of Sugar Tree School. In the gorge of Greenbrier River 1½ miles east of Alderson it outcrops along the Chesapeake and Ohio Railway on either side of the Monroe-Greenbrier County line, and within the limits of Alderson its upper part is exposed along the Alderson Anticline.

In Giles County, Virginia, the Union Limestone is partly exposed along the Norfolk and Western Railway on the west side of New River as noted in the Lurich Section, page 204, its upper boundary being apparently concealed but there being 175 feet of the lower portion visible, with marine fossils and with a little black chert, which is rarely found at this level of the Greenbrier.

In Mercer County it may be followed westward along the East River Valley at various points. In the Stony Gap Section, page 199, it is 262 feet thick, as exposed partly on the south side but mostly on the north side of the Norfolk and Western Railway just east of the Bluefield Water Plant, and contains abundant marine fossils among which were noted blastoids **(Pentremites)**, brachiopods, crinoids (including **Platycrinus huntsvillae)**, and horn corals. Here **Fossil Lot 116 on Map II** was collected by the writer across the entire outcrop including both the Gasper and Fredonia portions which had not then been separately distinguished, as was the case with some of the other early observations, but later **Fossil Lot 295 on Map II** was secured from the Fredonia portion mostly along the railroad track, a specimen of **Platycrinus huntsvillae** being found in this latter collection. Both lots have been studied by Dr. Girty whose complete lists will be found in Chapter XVIII.

In the eastern end of Bluefield and north of the railroad this limestone has been quarried at several points.

In the western part of the county it is very well exposed where the Abbs Valley Anticline crosses Bluestone River, as exhibited below:

McDowell County Stone Quarry.
(Leased to B. K. Newell & Company).

Beaver Pond District, Mercer County; on the north side of Bluestone River 0.1 mile northwest of Nemours Post-Office; dip, southeast; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Greenbrier Series (265')		
1. **Limestone, Union,** dark-blue, with marine fossils.	15	15
2. **Limestone, Union,** yellow, shaly.....	40	55

		Thickness. Feet.	Total. Feet.
3.	**Limestone, Union,** yellow, hard	40	95
4.	**Limestone, Union,** blue, hard	10	105
5.	**Limestone, Union,** gray, hard	15	120
6.	**Limestone, Union,** dark, hard	10	130
7.	**Limestone, Union,** yellow, hard, with marine fossils	25	155
8.	**Limestone, Union,** dark, hard	10	165
9.	Concealed by debris to base of quarry	25	190
10.	**Limestone, Pickaway,** gray and dark mixed, in old quarry and railway cut west of main quarry, visible	75	265
	Collection from Nos. 1 and 7 of section, corals, crinoids, brachiopods, blastoids (**Pentremites**), and bryozoa (see **Lot 127**).		

At the above exposure the upper boundary of the Union Limestone does not appear to be included and its lower limit is not perfectly clear, since there is a concealed interval of 25 feet at the base of the quarry, but it is evident that the formation must be nearly 200 feet thick and possibly more. **Fossil Lot 127 on Map II** was collected by the writer, a more detailed list of its fauna, as studied by Dr. Girty, being published in Chapter XVIII.

This quarry is owned by McDowell County and its product is used for road material, as will be further discussed in Chapter XIV under the subject of "Limestone".

The Union Limestone is preeminently a pure calcareous deposit, having very little chert or other impurities which make many of the other members of the Greenbrier Series unfit for use as a source of general lime products. In most parts of the three counties it is well suited for the production of agricultural lime, Portland cement, and for many other similar purposes, and it is also very good material for road macadam and general construction work where a fire-proof aggregate is not required. As previously stated it is frequently oolitic and might therefore be considered as a possible source of masonry stone, but its fracture and cleavage are predominantly conchoidal, making it of little value in this particular. In Chapter XIV will be found a description of various quarries and advantageous exposures, together with chemical analyses and a more detailed statement concerning its economic utilization. A partial view of this member is exhibited in Plate XXII.

PICKAWAY LIMESTONE.

The **Pickaway Limestone** (new) is a very dark, hard, and sandy deposit belonging immediately below the Union Limestone in the three counties under study, the interval of its top from the top of the Greenbrier Series varying from 200 to 600 feet, depending on the locality. Its thickness ranges from 175 to 400 feet so that in the region of maximum intervals its base occurs about 1000 feet below the top of the series. Through most of Monroe County its structure is almost entirely stylolitic, the ledge having been compressed into vertical columns or slabs by the forces of lateral thrust which operated in that region. Between the columns or slabs there is often a dark film of siliceous matter, giving its surface an irregular checkered appearance at many points. This stylolitic structure is confined almost entirely to the Pickaway Limestone and is usually a perfect guide to its identification in Monroe County, but the same condition is not general in Mercer. In regions where it has been exposed at the surface for a long time the calcareous matter weathers out almost entirely so that it often has the appearance of coarse, brown sand but when quarried to a depth of a few feet its character as a limestone becomes apparent. It contains a scanty marine fauna consisting mainly of brachiopods, gastropods, bryozoa, blastoids, and crinoids, but in localities where its stylolitic structure is best developed these organisms are often compressed and largely obliterated.

Its type locality is in Monroe County along the State road between Pickaway and Union where for a distance of three or four miles its characteristic features as above described are fully displayed in quarries, highway cuts, and natural reefs. Plate XXIV shows a very good view of its stylolitic condition slightly north of Union.

It does not appear that the Pickaway Limestone correlates with any other previously described formation in other States outside of the two Virginias. When traced northeastward it disappears in the northern part of Pocahontas County, West Virginia, and when followed southwestward it increases

to a maximum of nearly 700 feet in Washington County, Virginia, but it then declines rapidly in thickness and wholly disappears before reaching the boundaries of Kentucky and Tennessee.

In Monroe County a section of this limestone may not easily be measured at the type locality but in the Bickett Knob Section, page 224, it is very well exposed, being 235 feet thick in the public highway north of the knob. Here, in the lower 65 feet of the formation, there is a somewhat abundant fauna consisting mainly of bryozoa, crinoids, horn corals, and many large brachiopods, from which **Fossil Lot 174 on Map IV** was collected by Dr. Girty and the writer, and may be considered as the type collection. The complete list of these fossils by Dr. Girty will be found in Chapter XVIII.

On the west side of Swoopes Knobs this limestone is again exhibited in the Elmhurst Section, page 222, having a recorded thickness of 315 feet, but this is probably excessive since there is a westward dip for which no correction was made. Along the Abbs Valley Anticline west of Swoopes Knobs it may be noted at various localities on either side of the arch from Broad Run of Wolf Creek southwestward for about six miles, and on the same fold it is again exposed along the Indian Creek road for a distance of one-half mile or more just east of Greenville and finally goes under drainage where the anticline crosses Cooks Run about three-fourths mile south of Greenville.

East of Swoopes Knobs it may be recognized not only at the type locality above described but at many other points in the plateau north and south of Union. **Fossil Lot 145 on Map IV** was collected by the writer in the road and field 0.7 mile S. 18° E. of Monitor in an exposure that is apparently the lower part of the Pickaway Limestone, the ledge being granular and containing an abundant fauna with brachiopods, bryozoa, crinoids, horn corals, and a few blastoids **(Pentremites)**, as more fully described by Dr. Girty in Chapter XVIII. Just northwest of Union there are some very good exposures on the road which later ascends Swoopes Knobs toward Knobs village, and just south of Union it is visible at many points

for three or four miles along the Willow Bend road. West of Willow Bend it is prominent on the Turkey Creek road and for a short distance on the road toward Dropping Lick.

In the narrow belt of overturned Greenbrier strata in southwestern Monroe County it is present but was not examined in detail, but in the edge of Giles County, Virginia, it is partly exposed in the narrows of New River along the Norfolk and Western Railway, as recorded in the Lurich Section, page 204, but these observations were made before the formation had been fully differentiated so that its lower boundary was not recognized.

In Mercer County it may be followed westward along the valley of East River but must be recognized without aid of the stylolitic structure which is so prominent in Monroe, this feature having largely disappeared. In the Stony Gap Section, page 199, is is recorded as 418 feet thick, being partly blue and partly yellow with a ten-foot bed of shaly, calcareous sandstone separating it from the Fredonia portion of the Union Limestone and with five feet of gray, oolitic Taggard Limestone just below it and distinguishing it from the Patton Limestone which next underlies the Taggard in that locality. Here it contains a fairly abundant marine fauna throughout its thickness. **Fossil Lot 115 on Map II** was collected by the writer from the upper 258 feet, there being bryozoa, brachiopods, crinoids, horn corals, and gastropods, and **Fossil Lot 114 on Map II** was also collected by the writer from the lower 160 feet, there being bryozoa and numerous brachiopods. Both these lots were studied by Dr. Girty whose report is contained in Chapter XVIII. This exposure is in the ravine which enters Bluestone River just east of the Bluefield water pump station, there being a quarry in the upper 75 feet on the land of Ward Bailey immediately south of the Norfolk and Western Railway as later described in Chapter XIV. From this point westward to the Virginia line this member may not easily be studied, since its horizon is mostly covered by the railroad tracks and other culture of the city of Bluefield.

From an economic standpoint the Pickaway Limestone is quite generally too impure to be used where a high-grade

limestone is required, there being a large amount of silica and quite often an excess of magnesium carbonate. It is usually hard and durable, however, and makes excellent material for road macadam and other purposes where fire-proof material is not required, but it does not quarry into smooth blocks and would not be fitted for masonry structures. A description of various quarries, together with chemical analyses, will be found under the subject of "Limestone" in Chapter XIV.

UPPER TAGGARD SHALE.

The **Upper Taggard Shale** (new) is a red deposit sometimes 10 to 15 feet in thickness belonging just beneath the Pickaway Limestone and just above the Taggard Limestone and being one of the very few strata of this character that occurs in the Greenbrier Series of the three counties. Its type locality is in Monroe County in the road just north of Taggard Branch of Indian Creek 2.8 miles southeast of Union, as exhibited in the Local Measurement at **Fossil Lot 256 on Map IV** under the description of the Taggard Limestone on a later page. Here it is five feet thick and is a plain red shale apparently without marine fossils, as is the case at most of its exposures elsewhere. In connection with the Taggard Limestone and Lower Taggard Shale it is a valuable marker for the correlation of the strata in the middle portion of the Greenbrier Series. It occurs at various points in Monroe county some of which will be detailed under the description of the Taggard Limestone, but in Mercer County it largely, if not entirely, disappears. Farther northeast, however, it may be followed by somewhat intermittent exposures toward the head of the Greenbrier Valley.

TAGGARD LIMESTONE.

The **Taggard Limestone** (new) is a bed of white oolite coming between the Upper Taggard Shale and Lower Taggard Shale and in the region of maximum intervals slightly more than 1000 feet below the top of the Greenbrier Series and nearly 800 feet above the base. It is usually medium-soft

and quite pure and contains somewhat scanty marine fossils among which brachiopods, crinoids, bryozoa, and blastoids **(Pentremites)** have been noted. It is readily distinguished by its white color which stands out in contrast to the dark Pickaway Limestone slightly above it and to the dark, hard Patton Limestone slightly below it, and further, by its association with the Upper and Lower Taggard Shales which are usually red, and in addition by its very pronounced oolitic structure. Its type locality is in Monroe County on Taggard Branch where the following local measurement was secured:

Local Measurement at Fossil Lot 255.

Union District, Monroe County; in road just north of Taggard Branch of Indian Creek 2.8 miles southeast of Union; gentle northwest dip; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Greenbrier Series (25′)			
1.	**Limestone, Pickaway,** very sandy, forms most of hill to north	..	..
2.	**Shale, Upper Taggard** (type locality), red	5	5
3.	**Limestone, Taggard** (type locality), white, oolitic (2035′ B.); contains marine fossils, blastoids (Pentremites), brachiopods, and crinoids (see Lot 256)	5	10
4.	**Shale, Lower Taggard** (type locality), red	5	15
5.	**Limestone, Patton,** shaly, with marine fossils, to Taggard Branch	10	25

At the above locality Mr. Price and the writer collected **Fossil Lot 256 on Map IV,** the more complete list of its fauna, as studied by Dr. Girty, being published in Chapter XVIII.

On the south side of Taggard Branch just slightly south of the type locality it is again visible at elevation 2075′ B., where it has the same structure. Farther south it is exposed in the road on a branch of Turkey Creek 0.7 mile south of Willow Bend where it occurs near the middle of a bed of green, sandy, and slightly calcareous shale having a total thickness of 50 feet, of which the white oolite is but a small portion. The shales above and below the limestone, although not red, apparently represent the Upper and Lower Taggard Shales and contain a few small brachiopods. Here the strata dip southeastward being partly overturned. Farther north the

oolite is again visible at elevation 2320′ B. in a high ridge road 0.8 mile westward from Oak Grove School and 0.7 mile southeast of Monitor. At this point **Fossil Lot 152 on Map IV** was collected by the writer, there being brachiopods and blastoids **(Pentremites)**, as more fully listed by Dr. Girty in Chapter XVIII. Farther west a good exposure of the Taggard Limestone occurs at the following locality:

Local Measurement at Fossil Lot 150.

Second Creek District, Monroe County; on Pickaway-Sinks Grove road 1 mile northwest of Pickaway; steep southeast dip; traverse westward; arrangement in descending stratigraphic order.

		Thickness. Feet.	Total. Feet.
Greenbrier Series (125′)			
1.	**Limestone, Pickaway,** blue	25	25
2.	**Limestone, Taggard,** mostly gray, oolitic	10	35
3.	**Limestone, Taggard,** yellow	30	65
4.	**Limestone, Taggard,** blue, with marine fossils	20	85
5.	**Limestone, Taggard,** yellow, shaly, with marine fossils	15	100
6.	Concealed, with shaly limestone	15	115
7.	**Shale, Lower Taggard,** red	10	125
8.	Limestone, very sandy	..	...
	Collection from Nos. 2, 4, and 5 of section; brachiopods, horn corals, blastoids **(Pentremites)**, and bryozoa (see **Lot 150**).		

Fossil Lot 150 Map IV was collected by the writer at the above locality, a more complete list of the fauna being published by Dr. Girty in Chapter XVIII. East of Swoopes Knobs it is again visible at elevation 2240′ B. in the road 0.3 mile northwest of Ewing School and 1.3 miles southward from Sinks Grove, being grayish-white, oolitic, and 10 feet thick. In the Bickett Knob Section, pages 224-5, it occurs in the public road at elevation 2480′ B., having the red shales above and below it and containing fragments of crinoids and bryozoa, from which **Fossil Lot 175 on Map IV** was collected by the writer, as listed in more detail by Dr. Girty in Chapter XVIII.

On the Sinks Grove-Wolf Creek road one mile west of Sinks Grove it occurs at elevation 2150′ B. with its typical color and structure and associated with red shale. Farther north in the edge of Greenbrier County it is visible in the road

along the eastern base of Flattop Mountain 0.4 mile west of Perry School, being gray, oolitic, and bedded in sandy limestone at elevation 1945′ B. On the west side of Swoopes Knobs it is recorded in the Elmhurst Section, page 222, being gray and oolitic at elevation 1885′ B., and having red shale below it, the strata above being partly concealed.

In the extreme southwestern corner of Monroe County it is visible in the road on Trigger Run of Rich Creek one-fourth mile south of the main State road and 1.8 miles east of Peterstown, being gray, oolitic, and associated with red shales at elevation 1805′ B., and having a southeastward dip of 30 degrees along with the other overturned strata of that region.

In Mercer County it is recorded in the Stony Gap Section, page 199, coming directly between the Pickaway and Patton Limestones without any associated red shale, and having a gray color and oolitic structure.

Northeastward from the three counties it may be found at intervals in the Greenbrier Valley and as far northward as the head of Tygart Valley River in Randolph County, and southwestward it was traced as far as Washington County, Virginia, where it contains **Platycrinus huntsvillae**, a fossil which has seldom been found outside of the boundaries of the Fredonia portion of the Union Limestone but which clearly occurs in some of the new beds described in this Report.

At various points the structure and texture of this limestone would apparently be ideal for building stone but it is so thin that little use of it could be made for this purpose. As a correlation plane, however, it is of much value in the study of the Greenbrier Series.

LOWER TAGGARD SHALE.

The **Lower Taggard Shale** (new) is a deposit of red or sandy shale, coming just below the Taggard Limestone and just above the Patton Limestone, its thickness being usually 10 to 20 feet. Its type locality is in Monroe County on Taggard Branch of Indian Creek 2.8 miles southeast of Union, as exhibited in Local Measurement at **Fossil Lot 256 on Map IV,**

page 477. Here it is only five feet thick but elsewhere in the same county it is often more prominent, its principal exposures being noted under the description of the Taggard Limestone on the preceding pages, as well as in the Bickett Knob Section, page 225, and the Elmhurst Section, page 222. It does not appear to extend westward into Mercer County but northeastward it may be found at various points through the Greenbrier Valley as far as Pocahontas County. Its principal value is as a marker for the Taggard Limestone.

PATTON LIMESTONE.

The **Patton Limestone** (new) is a heavy and usually massive bed belonging just under the Lower Taggard Shale, and having its top about 1050 feet below the top of the Greenbrier Series in southern Mercer but only about 550 feet in northern Monroe County. As a rule it is somewhat shaly and sandy at the top but in the middle and lower portions it is hard and blue, weathering to a gray color, there being occasional nodules of black chert, although it is generally more free from impurities than most of the other members of the series. Its thickness varies from 100 to 250 feet and it usually contains scattered marine fossils among which brachiopods, crinoids, horn corals, bryozoa, and blastoids (**Pentremites**) were observed, and at a few points a plant fossil zone was noted in the middle portion. Its type locality is in Monroe County on the south side of Second Creek just south of Patton where, as indicated in the Patton Section, page 228, its base is visible at elevation 1950′ B., in the steep private road southeast of the village, and it extends upward 210 feet to another private road which turns off eastward from the main public road at the top of the plateau about one-half mile south of Patton. Here it is somewhat sandy, flaggy, and shaly at the top, but farther down becomes gray and generally pure although there are occasional nodules of black or gray chert, but the lower bench of 40 feet is a gray, pure, cavernous limestone with marine fossils among which brachiopods and crinoids were noted. Just below it the Sinks Grove Limestone is visible, this latter

PLATE XXVI.—View of overturned Keefer Sandstone in gap of Beaver Pond Creek just south of Bluefield Fair-Grounds, edge of Tazewell County, Virginia, looking east. Dip is now southeast with younger Clinton and Helderberg beds at left and older Clinton at right. (Photo. by Palmer & Fowler).

formation being distinguished from the Patton by its dark color and great abundance of black chert.

In the Bickett Knob Section, page 225, it is partly but not entirely exposed along the road from Bickett Knob to Sinks Grove, its total thickness being 275 feet and its character in general much the same as at the type locality. **Fossil Lot 176 on Map IV** was collected by the writer from a 55-foot bench of pure limestone coming 85 feet below the top, its fauna including brachiopods, crinoids, and horn corals; and **Fossil Lot 177 on Map IV** was also collected by the writer from the lower 80 feet of the formation, there being crinoids, blastoids **(Pentremites)**, horn corals, and bryozoa. These two lots, which have been designated as the type collections, have been studied by Dr. Girty whose more detailed lists appear in Chapter XVIII. At this locality the base of the member is again well distinguished from the underlying Sinks Grove Limestone which is blue or yellow and contains an abundance of black chert as contrasted to the relatively pure character of the Patton.

In the Elmhurst Section, page 222, the Patton Limestone is gray, massive, and 205 feet thick, as exposed at Big Cove School just north of Elmhurst but it is not certain that its base is above drainage and the recorded thickness of the visible portion may be slightly excessive, since the strata dip westward at that locality.

In the rolling country northeast of Union a good exposure of part of the Patton Limestone is visible along the Pickaway-Hillsdale road and in this region **Fossil Lot 146 on Map IV** was collected by the writer from a prominent 75-foot reef in the field of Nelson Hawkins 0.6 mile southeast of Pickaway, there being gastropods, horn corals, crinoids, bryozoa, brachiopods, and blastoids **(Pentremites)**, as more fully listed by Dr. Girty in Chapter XVIII.

In the region southeast of Union reefs of this limestone may be observed at various points but there are few localities where it may be readily measured and conditions are much the same in the narrow belt of overturned Greenbrier in southwestern Monroe. In the edge of Giles County, Virginia, it

is visible in the cut of the Norfolk and Western Railway on the west side of New River as recorded in the Lurich Section, page 204, but at this locality its upper boundary was not differentiated, the section having been measured before the essential differences of the various Greenbrier members had been fully determined. Its base, however, directly overlies the Patton Shale and there contains plant fossils. Above this shale, which will be later described, there is a bench of 115 feet of hard, gray Patton Limestone followed above by two feet of shaly limestone containing plant fossils. In this latter zone **Fossil Lot 232 on Map II** was collected by Dr. David White, Mr. Price, and the writer, the discussion of which by Dr. David White will be found in Chapter XVII. Above these plant fossils, which must be near the middle of the Patton Limestone, there is another exposure of 408 feet of gray, hard limestone of which the lower portion evidently belongs to the Patton.

West of New River the limestone may be followed up the valley of East River but at most points its exposures are not easily measured. In the Stony Gap Section, page 199, it was studied in the ravine southeast of the Bluefield water pump station on the south side of East River and can there be distinguished without difficulty, being shaly and weathering yellow, with streaks of sandy shale and shaly sandstone, and being bounded above by the gray oolitic Taggard Limestone and below by the dark Sinks Grove Limestone which contains much black chert. At this locality the calcareous portion of the Patton contains marine fossils among which brachiopods, crinoids, and some bryozoa were noted from which **Fossil Lot 113 on Map II** was collected by the writer as studied and listed by Dr. Girty in Chapter XVIII. The full thickness of the formation in this ravine is 234 feet.

In the immediate vicinity of Bluefield the Patton is largely covered by the culture of the city, its outcrop passing directly through the thickly populated territory between the Norfolk and Western Railway and the first ridge to the southward.

So far as known the occurrence of the Patton Limestone is entirely confined to the two Virginias, there being little or

no sediments reported or observed at its horizon in other States. Southwest of Bluefield it increases in thickness until it reaches an apparent maximum of 475 feet in Washington County, Virginia, but it then declines and disappears before reaching the borders of Kentucky and Tennessee. In southwest Virginia it contains **Platycrinus huntsvillae** and also a branching coral, **Syringopora,** which was not noted in the same beds of Monroe and Summers Counties, but which does not appear to have special diagnostic value since it is also found in some of the other lower members of the Greenbrier. Northeastward in West Virginia this limestone was recognized as far as the head of Greenbrier River in Pocahontas County where it still contains **Pentremites** but farther north it apparently disappears from the series.

From an economic standpoint the Patton Limestone is second in importance only to the Union Limestone of the Greenbrier Series, there being many exposures of comparatively pure material which could be used for many purposes where good limestone is desired, including agricultural lime and Portland cement. In Chapter XIV under the subject of "Limestone" various further exposures, together with chemical analyses, will be detailed.

PATTON SHALE.

The **Patton Shale** (new) is a gray and highly calcareous but somewhat lenticular deposit, varying in thickness from 10 to 20 feet, when present, and separating the Patton Limestone from the Sinks Grove Limestone and being of much scientific interest because of the somewhat abundant plant fossils which it often contains in addition to the usual marine fossils that may be expected in any portion of the Greenbrier. It is named from association with the Patton Limestone but was not observed at the type locality of the latter. One of its best exposures, which may be regarded as typical, is in Monroe County northeast of Union along the Pickaway-Hillsdale road 0.8 mile southeast of Pickaway, where it is 25 feet thick and consists partly of yellow, shaly limestone and partly of calca-

reous shale, its dip being there northwestward at the rate of about 15 degrees. At this locality it contains both plant and marine fossils with some small fragments of coal. **Fossil Lot 147 on Map IV** was collected from the marine fossils by the writer, there being brachiopods, crinoids, bryozoa, and blastoids **(Pentremites)**, as studied by Dr. Girty in Chapter XVIII. **Fossil Lot 228 on Map IV** was collected from the plant fossils by Dr. David White, Mr. Price, and the writer, as discussed by Dr. White in Chapter XVII.

In the edge of Giles County, Virginia, this shale was again observed in the cut of the Norfolk and Western Railway on the west side of New River, as recorded in the Lurich Section, page 204, being there 15 feet thick, calcareous, and separating the Patton Limestone from the Sinks Grove Limestone and containing plant fossils. At this point **Fossil Lot 231 on Map II** was collected by Dr. David White, Mr. Price, and the writer, as discussed by Dr. White in Chapter XVII.

From the abundance of plants at the two localities above described it appears probable that various other exposures of this most interesting shale could be found in the two counties. The shale itself was observed as far southwestward as Washington County, Virginia, where it reaches a thickness of 180 feet but where no plant fossils were observed although it was not carefully examined. Southwest of the Virginia State line it has apparently disappeared along with its associated limestones. Farther northeast in West Virginia, in Pocahontas County, it is sometimes represented by a thin bed of red shale.

SINKS GROVE LIMESTONE.

The **Sinks Grove Limestone** (new) coming just below the Patton Shale, when that lenticular bed is present, but otherwise just below the Patton Limestone, is a blue, hard, somewhat sandy and impure deposit sometimes weathering yellow toward the top but more usually becoming gray after long exposure, and containing throughout its mass a vast amount of black, nodular, carbonaceous chert which weathers gray. It

also contains many marine fossils both in the matrix and in the chert, among which brachiopods (including **Productus** and **Orthotetes**), bryozoa, crinoids, horn corals, and a few blastoids (**Pentremites**) have been noted. Its thickness in Monroe and Summers Counties varies from 175 to 330 feet, depending on the locality, and it is probably best identified by study from the base of the Greenbrier Series upward, since it is only 50 to 150 feet above the base of the series and directly overlies the Hillsdale Limestone, the peculiarities of which will be later described.

Its type locality is in Monroe County in the vicinity of Sinks Grove village, as recorded in the Bickett Knob Section, page 225. Here it makes an extended exposure, its top being at elevation 2265' B. along the Sinks Grove-Knobs road, while its middle portion makes prominent reefs in the environs of Sinks Grove and along the road to Spider Den School, and east of the school its lower portion is largely weathered out into chert which has become gray on long exposure, and the total measured thickness of the member being 167 feet. **Fossil Lot 178 on Map IV** was collected by the writer from the yellow 45-foot portion at the top, there being bryozoa, brachiopods, crinoids, and horn corals, as listed in detail by Dr. Girty in Chapter XVIII. **Fossil Lot 179 on Map IV** was also collected by the writer from the blue, hard, and very cherty portion outcropping between Sinks Grove and Spider Den School, part of the specimens being from the chert and part from the matrix, including brachiopods, crinoids, bryozoa, and horn corals, as discussed by Dr. Girty in Chapter XVIII.

In the region northeast of Union **Fossil Lot 148 on Map IV** was collected by the writer from a 25-foot bed of chert and yellow limestone in the Pickaway-Hillsdale road 0.3 mile northwest of Hillsdale, probably representing part of the lower portion of the Sinks Grove Limestone. This fauna consists of bryozoa, crinoids, and brachiopods, as listed by Dr. Girty in Chapter XVIII.

In the region southeast of Union heavy reefs of Sinks Grove Limestone may be observed at numerous points. Along the ridge road 0.3 mile southwest of Schley School and one

mile northwest of Gates, **Fossil Lot 130 on Map IV** was collected by the writer from an exposure of 50 to 100 feet of gray, angular chert at elevation 2260′ B., the fauna being mostly bryozoa, with a few brachiopods and crinoids, as listed by Dr. Girty in Chapter XVIII. The formation may also be followed in the overturned beds in southwestern Monroe County.

In the edge of Giles County, Virginia, it is visible in the cut of the Norfolk and Western Railway on the west side of New River, as noted in the Lurich Section, page 204, but it was not there distinguished from the underlying Hillsdale Limestone which had not been differentiated when the measurement was made, the total thickness of the two being 258 feet with a somewhat varied fauna.

In Mercer County it is quite well exposed on Pigeon Creek 0.3 mile above its mouth and 0.8 mile southeast of Oakvale, being blue, hard, and containing black chert and being now overturned with a present southward dip of 39 degrees. **Fossil Lot 108 on Map II** was collected by the writer at this locality, there being numerous brachiopods and also bryozoa, as listed by Dr. Girty in Chapter XVIII.

Farther west it is almost fully exposed in a ravine southeast of the Bluefield water pump station and southwest of Ada, as recorded in the Stony Gap Section, page 199. Here it is mostly blue and hard with a great amount of nodular black chert, and is in excess of 300 feet and probably nearly 400 feet thick but was not differentiated from the underlying Hillsdale Limestone at the early stage of field work when the section was measured. **Fossil Lot 112 on Map II** was collected from the upper 300 feet, the fauna being largely brachiopods, including numerous **Orthotetes,** as listed in more detail by Dr. Girty in Chapter XVIII. **Fossil Lot 111 on Map II** was also collected by the writer from the basal 243 feet of the Greenbrier Series at this locality and probably includes all of the Hillsdale Limestone and part of the Sinks Grove, the fauna being listed by Dr. Girty in Chapter XVIII.

So far as known the Sinks Grove Limestone was deposited in small quantity, if at all, outside of the limits of the two Virginias, there being no recorded occurrences of such a forma-

tion elsewhere. From Bluefield southwestward it increases in thickness and reaches an apparent maximum of 415 feet in Washington County, Virginia, but southwestward becomes thinner and disappears before reaching the Kentucky and Tennessee State lines. Northeast of Monroe County it gradually thins out and apparently does not extend entirely to the head of Greenbrier River.

From an economic standpoint the Sinks Grove Limestone could be used for road macadam or concrete aggregate where fire-proofing is not required, but it would not make good masonry structures, and it is chemically too impure for use as agricultural lime, Portland cement, or other purposes where high-grade material is wanted. For further discussion of it, together with chemical analyses, see Chapter XIV under the subject of "Limestone".

HILLSDALE LIMESTONE.

The **Hillsdale Limestone** (new) is the basal deposit of the Greenbrier Series in the three counties, its position being just under the Sinks Grove Limestone and just above the shaly or weakly calcareous beds of the Maccrady Series. As a rule it is blue, hard, and massive at the top, but toward the base contains streaks of sandy shale and throughout its mass from top to bottom the calcareous portions contain abundant nodules of black chert which weather to gray, and also marine fossils which are scanty in the chert but which occur in great numbers in the limestone matrix, corals (especially **Lithostrotion**), brachiopods (including **Productus** and **Orthotetes**), bryozoa (including fenestelloids), crinoids, and gastropods have been noted. Its thickness varies from 50 to 150 feet but apparently seldom reaches the latter figure. Its type locality is in Monroe County in the road just east of Hillsdale on the western limb of the Hillsdale Anticline, where it appears to be about 50 feet thick, being bounded above and northwestward by the weathered chert of the Sinks Grove Limestone, and below and eastward by the red shales of the Maccrady Series. **Fossil Lot 144 on Map IV** was collected at this point

by the writer, the fauna including corals (especially **Lithostrotion**), brachiopods, crinoids, and bryozoa as specified by Dr. Girty in Chapter XVIII.

In the edge of Greenbrier County there is a very good exposure in the hill road 0.3 mile northeast of Maple Grove School and 1.5 miles south of Organ Cave where it is dark and contains a large amount of black chert and is apparently 75 to 100 feet thick and has very abundant marine fossils. **Fossil Lot 149 on Map IV** was collected by the writer at elevation 2130′ B. near the top of the formation, there being horn corals and brachiopods (especially **Productus** and **Orthotetes**) and also gastropods as detailed by Dr. Girty in Chapter XVIII.

In the Maple Grove School Section, page 229, it is 115 feet thick, being dark and containing much black chert with a little calcareous shale and having many marine fossils among which one brachiopod, which Dr. Girty calls **Productus** aff. **semistriatus**, is of much interest as will later appear. In the Hokes Mill Section, page 227, it is 125 feet thick and contains abundant black chert and numerous brachiopods. In the Patton Section, page 229, the portion exposed above the bed of Second Creek is 85 feet thick and contains the usual amount of black chert and some sandy shale together with horn corals, bryozoa, and brachiopods. In the Spider Den School Section, page 227, the exposed portion is 65 feet and probably represents most of the formation at that locality.

In the Bickett Knob Section, page 225, it is 48 feet thick and consists mainly of dark limestone with black chert but also contains a little sandy shale. **Fossil Lot 153 on Map IV** was collected by the writer from the calcareous portions, there being an abundant fauna among which were noted corals (**Lithostrotion**), brachiopods, bryozoa (especially fenestelloids), and crinoids, as specified by Dr. Girty in detail in Chapter XVIII.

From this northern part of the county its outcrop may be followed southward along the eastern edge of the Greenbrier outcrop. **Fossil Lot 140 on Map IV** was collected by the writer along a branch of Turkey Creek 1.3 miles south

of Willow Bend from the basal 50 feet of the formation as exposed in the field just west of the road which ascends this branch, the measures at this point being overturned and now dipping southeastward at the rate of 50 degrees. Here there is a profuse marine fauna including corals, bryozoa, crinoids, and brachiopods (especially **Productus**), as more fully detailed by Dr. Girty in Chapter XVIII.

In the overturned beds of southwestern Monroe it may be noted at various points but was not given special attention, and in the edge of Giles County, Virginia, where it is exposed in the cut of the Norfolk and Western Railway on the west side of New River as recorded in the Lurich Section, page 204, it was not differentiated from the overlying Sinks Grove Limestone.

In Mercer County it can be followed through the overturned beds on the south side of East River, being recorded in the Stony Gap Section, page 199, but not therein differentiated from the Sinks Grove Limestone. **Fossil Lot 111 on Map II** was collected by the writer at this locality in the ravine southeast of the Bluefield water pump station but is partly in the Sinks Grove Limestone so that its fauna as reported by Dr. Girty in Chapter XVIII does not belong strictly to the Hillsdale member.

Southwestward from Bluefield the Hillsdale Limestone was traced through southwest Virginia and into southwestern Kentucky where it corresponds to the limestone which Butts correlates as the St. Louis Limestone in his two reports on the Mississippian Series of Kentucky, as previously cited. Farther south the same formation extends across Tennessee to Lookout Mountain in the vicinity of Chattanooga and to Monteagle farther west where it was pointed out to the writer by Mr. Wilbur A. Nelson, State Geologist of Tennessee, as the St. Louis, and where, according to Mr. Nelson, it contains abundant **Lithostrotion.** From southern West Virginia southwestward through most of the region mentioned it also carries the same brachiopod which has been called **Productus** aff. **semistriatus** by Dr. Girty, from the specimen secured by the writer at the Maple Grove School Section in Monroe County.

The writer does not recall that this fossil was found in other members in the course of his study of the Greenbrier Series. As previously stated Dr. Girty has not agreed that the Hillsdale Limestone may be finally correlated with the St. Louis Limestone but will doubtless express his opinion on this subject in Chapter XVIII. The writer has not inspected the St. Louis Limestone at its type locality and for that reason and in view of the apparent conflict between the studies of Dr. Girty in West Virginia and the correlation of Mr. Butts in Kentucky prefers at present to simply aver that the Hillsdale Limestone is the same as that which has been called St. Louis in Kentucky and Tennessee, without expressing an opinion regarding its correlation with the Missouri type.

In West Virginia the Hillsdale Limestone may be followed northeastward to the vicinity of Marlinton, Pocahontas County, north of which it has not been noted and apparently disappears from the series.

ECONOMIC ASPECTS, GREENBRIER SERIES.

The weathered beds of the Greenbrier Series furnish a rich agricultural soil which has been sought with so much care by the early settlers of the three counties that scarcely an acre of its outcrop now remains in woodland, as contrasted to the almost totally uncleared areas of the Pocono and other arenaceous formations. In localities where the topography is rough or the surface of the limestone is not deeply enough eroded to form a tillable soil the outcrop is necessarily limited to grazing but in regions like that of the Harrisburg Peneplain through central Monroe County there are wide areas where the Greenbrier lands may be cultivated with good results.

As previously mentioned in detail many of the beds of this section make excellent material for road macadam and for concrete aggregate, for which purposes they have already been much employed around Bluefield and Union and some of them are suited for agricultural lime and for the manufacture of Portland cement, which latter industry the writer believes could be developed on a vast and profitable scale

through the Greenbrier Valley and across the southern ends of Monroe and Mercer Counties. In Chapter XIV, under the subject of "Limestone" will be found a further discussion of these economic features, together with detailed descriptions of quarries and with numerous chemical analyses of favorable exposures.

CHAPTER IX.

STRATIGRAPHY---MACCRADY AND POCONO SERIES.

GENERAL STATEMENT.

In southern West Virginia and in southwest Virginia the rocks of the Mississippian Period below the Greenbrier Series are contained in two distinct series of which the upper is the Maccrady (originally called Pulaski), consisting mainly of shale in West Virginia but being more complex in Virginia, and the lower is the Pocono (otherwise known as Price, Grainger, etc.), being largely made up of arenaceous beds with some shales and a few coals. These two series differ widely in their physical aspects but they have certain important points in common which make their discussion in the same chapter not inappropriate.

MACCRADY SERIES.

GENERAL ACCOUNT, MACCRADY SERIES.

The Maccrady Series, coming just below the Greenbrier and just above the Pocono, is a well-defined and distinct portion of the Mississippian Period in southern West Virginia. As originally named by Campbell[1] it was called the "Pulaski Shale" from its exposure in the county of that name in Virginia, but this title had been previously applied by Vanuxem to an Ordovician formation in New York so that Stose[2] renamed it the "Maccrady Formation" from its exposure in

[1]M. R. Campbell, Geol. Soc. Am. Bull., Vol. V, pp. 171, 178; 1894.
[2]G. W. Stose, Geology of the Salt and Gypsum Deposits of Southwestern Virginia, Bull. 530, U. S. Geol. Survey, pp. 232-255; 1913.

Smyth County, Virginia, and this title has gained gradual acceptance in the literature of the last decade. It has been the custom of the West Virginia Survey to avoid as far as possible the term "Formation" in the application of names to major subdivisions and it will therefore be called the **Maccrady Series** in the present Report, since it may not be grouped as a portion of any other series and since its various components in the region of its type locality are so complex that its eventual subdivision into smaller units or stages will be required before it can be adequately described.

The Maccrady Series at its outcrop in Mercer and Monroe Counties consists of deep red, purple, and argillaceous shales, yellow and calcareous shales, yellow earthy limestone, and weakly bedded, calcareous sandstone, there being a scanty marine fauna in some of the more calcareous beds and only a trifling display of fossil plants. Its thickness varies from 25 to 350 feet, the larger figures being found at some points in Monroe County, while in northern Summers County, it is shown by well records as disappearing almost entirely. In Mercer County its development is generally between these extremes.

In Smyth and other neighboring counties of Virginia, however, the Maccrady becomes thicker, being lately described by Stose[3] as in excess of 700 feet and having been recently measured by the writer at Saltville where it is 545 feet but where some of the lower beds which occur around Maccrady and Broad Ford appear to be absent. In this region it contains some quite well-defined sandstones and limestones in the upper third or half, followed below by nondescript red or purple shales, and still lower by black, carbonaceous shales that contain some tiny seams of coal, and having a very considerable marine fauna in the limestones or calcareous shales and sandstones of the upper part.

In southern West Virginia the black shales and incipient coals of the lower part have completelv disappeared and most of the limestones of the upper portion are also gone, leaving

[3]Gypsum Deposits of the United States, Bull. 697, U. S Geol. Survey, pp. 283-298; 1920.

little except the red and purple shales of the middle part and some fragmentary limestones and rather poorly defined sandstones.

SUBDIVISIONS, MACCRADY SERIES.

As above outlined it is apparent that the most favorable region for making a detailed subdivision of the Maccrady would be in the vicinity of its type locality in Smyth or other adjoining counties in Virginia where it contains several distinctive elements on which such a differentiation might be made and where some of these might be fortified by rather abundant paleontological collections if so desired, there being a possibility that they might be traced through enough territory to fix their value as correlation planes. No such favorable opportunity is afforded in southern West Virginia so that in the present Report no general section of the series will be published and no subdivisions will be made, but most of the available notes will be recorded for the use of future students of the series.

TOPOGRAPHIC EXPRESSION, MACCRADY SERIES.

In Mercer County the outcrop of the Maccrady occupies only a narrow strip of the overturned and nearly vertical beds that occur in the region between the St. Clair Fault and the valleys of East and Bluestone Rivers, being fortified on the north by the massive beds of the Greenbrier and on the south by the sandstone ledges of the Pocono and Chemung Series, so that its outcrop in this county is usually marked only by a smooth slope or by occasional low benches.

In southwestern Monroe County the outcrops and topography of the series are much the same as in Mercer, being only an eastern continuation of the same structure, but farther east in the drainage basins of Second Creek and Cove Creek, where the strata of the Mississippian have mostly resumed their normal position and are less inclined, the Maccrady outcrops are marked by gentle valleys or slopes, there being no durable ledges capable of making ridges or escarpments.

AREAL EXTENT, MACCRADY SERIES.

Figues 15 and 16, prepared by Mr. Price, show the outcrops of the Maccrady and Pocono Series in Mercer and Monroe Counties, respectively, but the two are not thereon differentiated since they occur in close conjunction and one is not usually found without the other. On Maps II and IV, however, the outcrops of both are shown in detail on a larger scale. In Mercer County, as previously stated, the Maccrady is confined to a narrow strip in the southern portion, starting at the Virginia State line just west of Bluefield and slightly south of the Norfolk and Western Railway and passing eastward through Bluefield in the vicinity of the Post-Office and thence eastward in the slope of the first ridge south of East River until it reaches Mills Valley where it passes to the north side of the river and railway, and for the next five or six miles crosses these landmarks two or three times, but just northeast of McKenzie Station it returns to the south side and so continues nearly to Wills Station where for a mile or two it is north of the river but finally crosses into Giles County, Virginia, about three-fourths mile south of Glenlyn. Throughout this entire outcrop the beds are overturned and now dipping southward, the outcrop being seldom more than 200 or 300 feet wide.

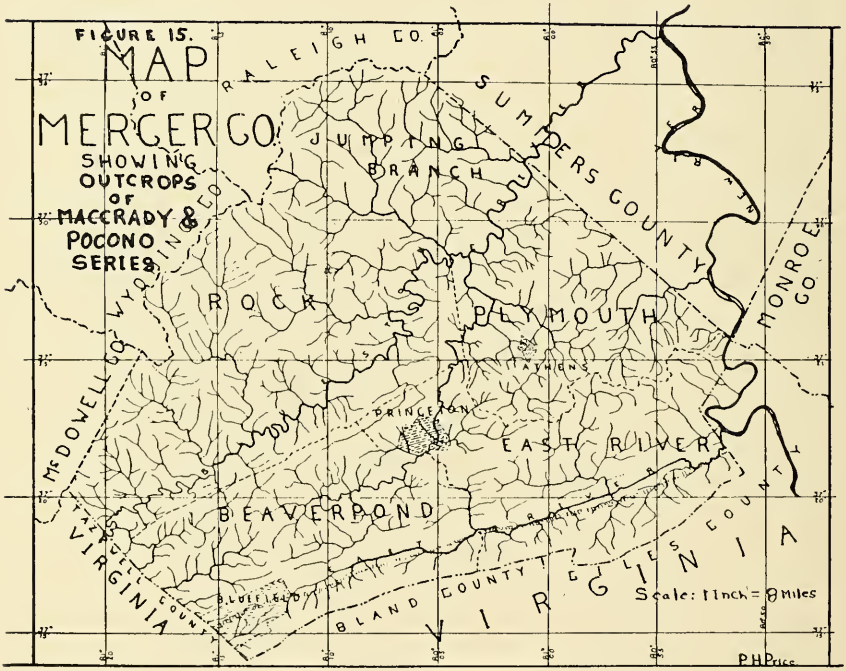
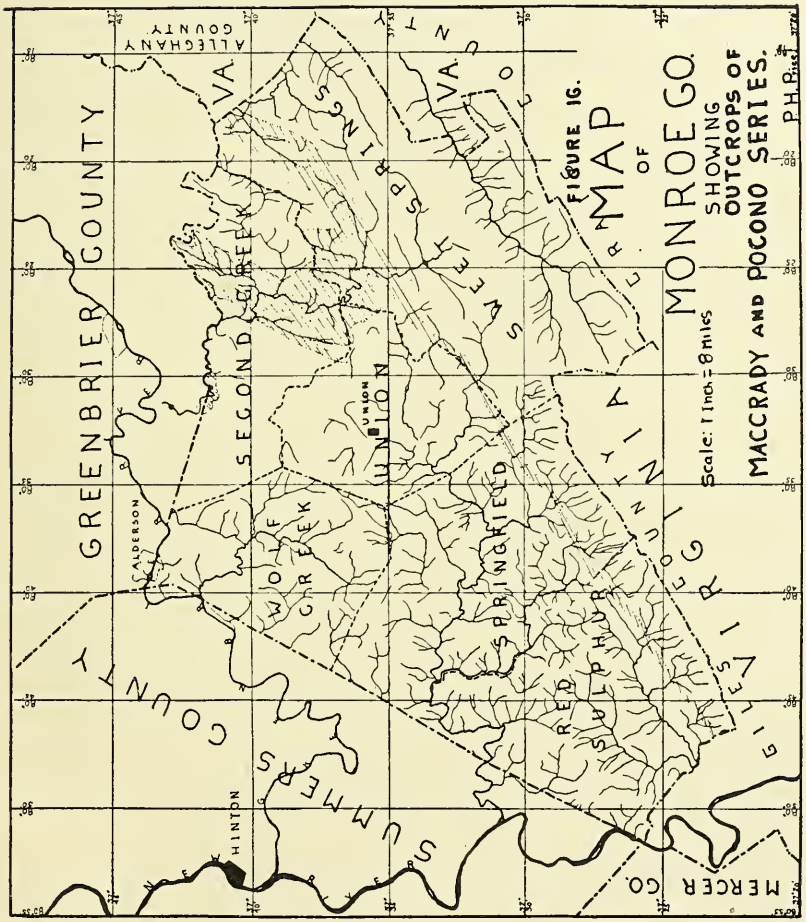


FIGURE 15.
MAP
OF
MERCER CO.
SHOWING
OUTCROPS
OF
MACCRADY &
POCONO
SERIES.
RALEIGH CO.
SUMMERS COUNTY
JUMPING
BRANCH
ROCK
PLYMOUTH
MONROE
CO.
WYOMING CO.
McDOWELL CO.
PRINCETON
EAST RIVER
BEAVERPOND
VIRGINIA
BLUEFIELD
BLAND
COUNTY
VIRGINIA
Scale: 1 inch = 8 miles
P.H.P.


GREENBRIER COUNTY
ALLEGHANY COUNTY
VA.
VA.
SUMMERS COUNTY
MERCER CO.
MONROE CO.
HINTON
CALDERSON
SECOND CREEK
WOLF CREEK
UNION
SPRINGFIELD
RED SULPHUR
SWEET SPRINGS
SUMMERS
FIGURE 16.
MAP
OF
SHOWING
OUTCROPS OF
MACCRADY AND POCONO SERIES.
Scale: 1 Inch = 8 miles
P.H.B.

Passing into the northern extremity of Giles County and crossing New River in the narrows about three-fourths mile south of Rich Creek, these beds enter Monroe County on the head of Scott Branch slightly less than 1½ miles southeast of Peterstown and thence continue northeastward, along the northern slope of the discontinuous range of hills known as Little Mountain, for approximately 24 miles to the vicinity of Red Mill. Here the Mississippian rocks again regain their normal position and become more gently inclined so that the Maccrady outcrop widens to a considerable territory, making a somewhat rolling valley, as exhibited in Plate XXV. Eastward from this valley it appears to be completely eroded along a mile or more of Devil Creek but the descending structure of the Pedro Syncline soon contains it again and it occupies the upper end of Devil Creek, passing into the valley of Cove Creek where it is divided into two limbs by the Greenbrier Series which still remains in the lowest part of the syncline. Farther northeast at Pedro the two limbs reunite and soon afterward the northeastward rise of the rocks carries the combined outcrops above the topography. This series is mainly responsible for the smooth lands that occur on the head of Devil Creek and on Cove Creek.

From the broad valley of Second Creek in the vicinity of Red Mill another part of the Maccrady outcrop extends generally northwestward across several more anticlines and synclines to the vicinity of Dorr and Hillsdale where it turns northeastward and follows mainly along the western side of Rayburn Draft to Second Creek village and thence continues to the Monroe-Greenbrier County line entering the latter county 1½ miles southeast of Organ Cave. Slightly farther east there is another area in the upper valley of Carpenter Creek, having a length of about 2½ miles and a width of about one-half mile. A few miles farther west the series is again brought above drainage in the valley of Second Creek along the Sinks Grove Anticline, the eastern end of its outcrop being just west of Patton from which it extends westward and follows along the steep slopes of the creek, partly in Monroe and partly in Greenbrier County, until is passes finally

into the latter just south of Hokes Mill; but along the summit of the arch it is well up toward the plateau, the lower valley of the creek being occupied by the Pocono.

CONTACTS, MACCRADY SERIES.

The upper contact of the Maccrady Series with the Greenbrier which next overlies it has already been discussed in connection with the latter series in Chapter VIII where it was pointed out that a disconformity at least equal to the several hundred feet of the upper beds of the Maccrady which exist in Virginia but which do not occur in West Virginia, must be assumed, and further that certain of the western groups of the Mississippian may also be lacking depending to some extent on the age determination of the Maccrady which has not been finally settled. In Mercer and Monroe Counties its basal portion is also missing by disconformity, allowing its red and purple shales to rest directly on the Pocono Series of which latter the upper beds are never present in Mercer and seldom in Monroe, so that the known disconformity between the two series is further increased by this circumstance. It is not now possible to state with certainty the extent of the unconformity that may exist at the base of the Maccrady when compared with the rock column of the Mississippi Valley since much work must be done to determine its relationship to the older Mississippian. Dr. Girty has surmised, or rather suggested, that its fauna to some extent resembles that of the Warsaw and if it should indeed prove to be of Warsaw age it is at once evident that a considerable hiatus exists between its base and the top of the beds which represent the Pocono in that region. The writer is inclined, however, to emphasize the doubt that exists in Dr. Girty's mind about a possible correlation between the Maccrady and Warsaw and it might be possible that the Maccrady belongs lower in the column so that the large unconformity comes at its top rather than at its base.

FOSSIL LIFE, MACCRADY SERIES.

In Mercer and Monroe Counties the marine invertebrate life in the Maccrady appears to be largely limited to a few

brachiopods, pelecypods, and bryozoa (fenestelloids), and possibly a few other classes, all of which occur sparingly and often are largely absent. In Mercer County **Fossil Lot 1 on Map II** was collected by Dr. Prouty and the writer in an excavation on Federal Street, just southwest of the West Virginian Hotel and just north of the Peery Building, in Bluefield, as recorded in the Bluefield Section, page 193. Here there is a considerable fauna in yellow, calcareous shale from which Dr. Prouty has identified **Spirifer** close to **bifurcatus, Fenestella** cf. **tenax,** and **Nucula** sp. These beds come above the red shale and would therefore belong in the upper half of the series at its type locality.

In Monroe County **Fossil Lot 214 on Map IV** was collected by Dr. Girty and the writer in the road along the east side of Dry Creek 0.5 mile southeast of Lindside, in a yellow, shaly limestone which comes just beneath the base of the Greenbrier Series in that locality and which is among the upper beds of the West Virginia phase of the Maccrady. This exposure reveals the presence of brachiopods and bryozoa with some pelecypods as specified in more detail by Dr. Girty in Chapter XVIII. Elsewhere in the two counties marine fossils were not observed in the Maccrady but at Bluefield, as recorded in the Bluefield Section above cited, there is a reddish-brown, coarse, and friable sandstone exposed behind the buildings on the west side of Bland Street, northwest of the Post-Office and near the City Building, which contains rather abundant plant fossils. This horizon is only five feet thick and is separated from the apparent top of the Pocono Series by 30 feet of yellow, sandy shale, and should not be confused with the Broad Ford Sandstone of the Pocono Series which has the same color but which is located farther south in the excavation made for the Bailey Building. No collection was obtained at the above locality.

In the Stony Gap Section, page 199, there is a 20-foot bed of limestone and calcareous shale exposed at the top of the series but revealing no fossils, being followed below by 112 feet of red shale and concealed material. In the Blake Section, page 201, the Maccrady is poorly exposed and no fossils

were observed; and in the Lurich Section, page 204, the same condition exists.

In northern Monroe County this series is 290 feet thick as recorded in the Bickett Knob Section, page 226, there being a shaly yellow limestone in which Dr. Girty and the writer failed to find fossils, followed below by red shale with streaks of sandstone toward the base. In the same region the series is 115 feet thick in the Spider Den School Section, page 227, but there appears to contain no limestone, being made up of red, green, or sandy shales with some shaly sandstone. In the Hokes Mill Section, page 228, the series is 175 feet thick and contains some yellow limestone with a little sandstone and various colored shales but does not appear to be fossiliferous. In the Maple Grove School Section, page 229, there is a gray, shaly limestone in the top of the Maccrady but nothing was observed in it. In the Brick Church Section of southern Monroe, page 217, the series is 195 feet thick and contains three streaks of yellow limestone together with various colored shales and some shaly sandstone. In the Gap Mills Section, page 230, it is 418 feet thick, which is the maximum observed in the two counties, and is made up mostly of red, purple, and variegated shales, with a little sandstone, no fossils being found.

CORRELATION, MACCRADY SERIES.

The correlation of the Maccrady Series with the Mississippian of other regions is a wholly unsolved problem. Stose, in the report where he first names it, says that it probably represents the lower part of the Mauch Chunk of Pennsylvania, but this idea can not be seriously entertained, since the Mauch Chunk belongs entirely above the Greenbrier Series while the Maccrady just as clearly comes below it. In the same citation he also says that Girty has correlated it with the Moorefield Shale of Arkansas, but Girty himself, in his previously cited paper on the Greenbrier Limestone and adjacent rocks, published in the Tucker County Report of the West Virginia Survey, says that the Maccrady fauna resembles that

of the Warsaw, although he regards the evidence as "very unsubstantial" and acknowledges that some of the fossils are common in the Keokuk.

It is true that the Maccrady at its type locality occupies a position quite the same as that of the Warsaw as it has been described in Kentucky and Tennessee, being immediately under the Hillsdale member of the Greenbrier which in those States corresponds to the formation classified as St. Louis; while the St. Louis is there placed directly over the Warsaw without any intervening Spergen. It is also true that in following the Maccrady westward through Virginia it loses the red and carbonaceous shales of its lower half before passing out of Washington County, since the sections at Mendota and Moccasin Gap show nothing except calcareous or gray, sandy beds. Farther west these shales disappear and a hard, yellow limestone containing round nodules of reddish-brown chert, which may perhaps be safely classified with the Warsaw, abruptly takes the place of the Maccrady but the two formations are so wholly dissimilar that much more convincing evidence must be found before they can be regarded as equivalent.

Northeastward and northward from southern West Virginia the Maccrady gradually disappears along with certain of the lower members of the Greenbrier Series until the Fredonia portion of the Union Limestone finally rests directly on the sandstones of the Pocono Series, and this relationship continues into central Pennsylvania where the Greenbrier itself finally disappears. In the eastern part of West Virginia and more particularly in Morgan County, however, there occurs in the upper part of the Pocono Series a red shale (Myers) which somewhat resembles the Maccrady but which can hardly by any reasoning be classified with it since the Myers Shale there underlies a great conglomerate which can be followed with scarcely a break across Maryland and into northeastern Pennsylvania while the Myers Shale itself may also be observed in diminished quantity at its proper place in the region named.

ECONOMIC ASPECTS, MACCRADY SERIES.

In Mercer and Monroe Counties the Maccrady Series has been of value only as a maker of agricultural soils, for which purpose it is admirably adapted, since not only its limestones and shales, but also its sandstones, readily disintegrate. Along the Holston River near its type locality in Smyth County, Virginia, some of the soft beds of this series are saturated or wholly replaced by valuable deposits of gypsum and rock salt which are being mined extensively but which are not regarded as primary portions of the stratification, being explained by Stose as due to the effect of circulating waters that have dissolved calcareous matter from the Cambrian limestones which are there faulted over the Maccrady. There is no evidence that such deposits occur in Mercer and Monroe Counties.

It is quite possible that some of the red and purple shales could be used for the manufacture of building brick or tile, since they are usually free from calcareous or organic matter and are quite plastic at some localities. Owing to their included iron they should burn to a rich red color.

POCONO SERIES.

GENERAL ACCOUNT AND SECTION, POCONO SERIES.

The Pocono Series, coming just under the Maccrady when the latter is present but just under the Greenbrier in regions where there is no Maccrady, is the basal major subdivision of the Mississippian in the three counties, as well as in the remaining counties of this State and in Maryland, Pennsylvania, and portions of other States farther west and south. The series was named Pocono by Lesley[4] in 1877, its previous designation having been the "Vespertine" or "No. X" of Rogers both of which were gradually abandoned as lacking in geographic association. In 1877 also it was described as Pocono by Stevenson, Ashburner, and Platt in other publications in evident agreement with Lesley's nomenclature.

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[4]J. P. Lesley, Preface to Report HH, Sec. Geol. Survey of Pa., pp. XXIV-XXVI; 1877.

As exposed in Mercer and Monroe Counties and as recorded in well records in Summers, the Pocono consists of gray or reddish-brown sandstones, most of which are coarse and much cross-bedded and some of which carry abundant quartz pebbles; and of sandy or carbonaceous shales, together with some impure and lenticular coals. Abundant plant fossils are found throughout most of the series and marine invertebrates occur in some of the sandstones and shales.

The following general section, prepared by the writer, illustrates the occurrence of the series in the three counties where it is as a rule poorly developed and less complex than in many other parts of the Appalachian region. A much more comprehensive section will be published in a future volume of more extensive geographic scope:

General Section of the Pocono Series for Mercer, Monroe, and Summers Counties.

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
1.	**Sandstone, Logan (Burgoon) (Big Injun Oil Sand)**, gray, massive, coarse, with frequent quartz pebbles; often shaly and cross-bedded; lenticular in this territory, being present at outcrop in some localities of southeastern Monroe County and being noted in a few well records in Summers County...	0 to 250	250	250
2.	Shales, gray, sandy; generally absent from southern Mercer and southwestern Monroe	0 to 50	300	
3.	**Sandstone (Squaw Oil Sand** of West Virginia Oil Fields), gray or dark, with occasional coal spars; correlation not definitely established; lenticular, generally absent from southern Mercer and southwestern Monroe County, but noted at oil test wells in Summers County.....	0 to 50	350	100
4.	Shales, sandy or dark, lenticular; generally absent from southern Mercer County	0 to 50	400	
5.	**Coal, Merrimac, or "Big Seam"**, of Montgomery County, Virginia; generally present at outcrop in Monroe County, but slaty, impure, lenticular, and apparently worthless; absent from southern Mercer and not noted in oil test wells of Summers County	0 to 5	405	55

		Thickness. Feet.	Total. Feet.	Intervals. Feet.
6.	Shale, sandy or dark, lenticular.....	0 to 9	414	
7.	**Sandstone, Lindside,** greenish-gray, or reddish-brown, sometimes ferruginous; absent from southern Mercer County but present in portions of Monroe	0 to 40	454	
8.	**Coal, Langhorne** or **"Little Seam"**, of Montgomery County, Virginia; present at a few outcrops in Monroe County but always impure and apparently worthless	0 to 1	455	50
9.	**Sandstone, Broad Ford (Weir Oil Sand** of Kanawha County is apparently part of this horizon), reddish-brown as a rule but sometimes greenish-gray or rusty or rarely gray, usually thick-bedded and frequently hard, but often shaly and weathering to concretionary or chunky blocks; usually carries several zones of marine fossils, brachiopods (**Syringothyris, Chonetes, Camarotoechia, Spirifer, Productus,** etc.), gastropods (**Bellerophon?**), crinoids, pelecypods, and cephalopods (**Orthoceras**) (see Lots 2, 15, 294, and 297); also carries occasional plant fossils (see Lot 110) and frequently the fucoid **Taonurus cauda galli**; generally present at outcrop in Mercer and Monroe Counties	50 to 250	605	150
10.	Shales, greenish-gray, sandy, with streaks of sandstone.....	25 to 95	700	
11.	**Shale, Sunbury (Coffee Shale** of West Virginia Oil Fields), black, fissile, and carbonaceous or greenish-gray and sandy; frequently contains marine fossils, brachiopods (**Lingula melie** and **Linguladiscina herzeri**) (see Lots 13 and 296); also contains plant fossils (**Calamites?**)	25 to 50	750	
12.	**Sandstone, Berea,** gray, massive, coarse, and hard, or cross-bedded and shaly; frequently carries numerous quartz pebbles; generally though not always present.....	25 to 150	900	295

In the above general section the sandstone which corresponds to the Squaw Oil Sand farther north is so uncertain and lenticular that it is given no title, in the belief that a more suitable exposure will be found in the outcrops of some other region.

SUBDIVISIONS, POCONO SERIES.

In the Potomac River region of eastern West Virginia and central Maryland the Pocono Series has been divided into major groups by Stose and Swartz[5] in the following descending order:

Pinkerton Sandstone
Myers Shale
Hedges Shale
Purslane Sandstone
Rockwell Formation.

The above divisions, which are quite logical and easily recognized in the region where they were made and which can be traced northeastward across Maryland without much difficulty and still farther into Pennsylvania with less certainty, do not appear to be wholly recognizable much farther southwestward in West Virginia and Virginia, since their very pronounced differences in lithology largely disappear, the distinctive red Myers Shale being apparently absent, while at the same time no marine fossils have yet been found in the Potomac region by which the beds can be connected with the marine Pocono of southern West Virginia and Virginia. These group subdivisions will therefore not be employed in the present Report and only the names of minor formations, or members, will be employed, but at the same time it is believed that certain relationships with the Potomac phase may be tentatively suggested, as will later appear.

TOPOGRAPHIC EXPRESSION, POCONO SERIES.

In both Mercer and Monroe Counties the Pocono beds produce a rough topography, the sharp features of which are much accentuated by the highly disturbed condition of the strata in the regions in which the series generally outcrops. There is no locality in either county where the topographic forms of the series are free from the influence of tectonic or other external agencies so that typical weathering is not

[5]George W. Stose and Charles K. Swartz, Pawpaw-Hancock Folio, No. 179, U. S. Geol. Survey; 1912.

readily apparent. In Mercer its overturned beds, together with those of the Chemung, generally make the first ridge south of East River and the same condition continues far across Monroe in the discontinuous hills known as Little Mountain. A partial view of this ridge in the latter county is exhibited by Plate XXV.

AREAL EXTENT, POCONO SERIES.

Figures 15 and 16, on previous pages of this Chapter, show the outcrops of the Maccrady and Pocono Series in Mercer and Monroe Counties, respectively, but as already explained the two series are not thereon differentiated since they occur in close conjunction and one is not usually found without the other. On Maps II and IV the outcrops of both are shown in detail on a larger scale. In Mercer the Pocono is confined to a narrow strip, starting at the Virginia State line just west of Bluefield and slightly south of the Norfolk and Western Railway, and passing eastward generally with the first ridge south of the railway and south of East River, there being some exceptions as noted on Map II. In Monroe this belt of narrow and overturned beds continues northeastward with the crest of Little Mountain to Red Mill and thence with Middle Mountain to Little Devil Creek where a tectonic change occurs and the belt divides, one outcrop continuing northeastward with the north slope of Middle Mountain on the south side of the Pedro Syncline until it reaches the line of Alleghany County, Virginia, while another parallels it on the south slope of Cove Mountain north of the syncline and eventually rejoins it before reaching the Alleghany County line. From Devil and Little Devil Creeks, also, another outcrop turns northwestward and crosses some low folds until it reaches Hollywood where it broadens and turns northeastward down Second Creek, including Eads Ridge and part of Daniels Ridge, but in the region east of Second Creek village it follows northward up the valley of Carpenter Creek, being divided by a remnant of the Maccrady, and finally passes into Greenbrier County at the southern end of White Rock Mountain. A par-

tial exposure of the series also occurs farther west near Nickells Mill where the Sinks Grove Anticline crosses Second Creek.

CONTACTS, POCONO SERIES.

The upper contact of the Pocono Series with the Maccrady has already been discussed in connection with the latter series. At its base it rests unconformably upon the Chemung Series of the Devonian, there being no vestige of the Catskill Series of the latter period which farther north in West Virginia and farther northeast in Maryland, Pennsylvania, and New York makes the upper subdivision of the Devonian and separates the Pocono from the Chemung. The absence of this body of red shales and red sandstones in southern West Virginia often causes the determination of the Pocono-Chemung boundary to be somewhat uncertain, since both series have much the same color and both carry marine fossils, there being now some very good evidence that some of the species formerly regarded as exclusively Chemung have survived into the Pocono. In most localities, however, the Pocono may be recognized by the more massive, cross-bedded, or conglomeratic nature of its sandstones, as compared to the generally thin flagstones of the Chemung, and also the black Sunbury Shale, which belongs just above the Berea (basal) member of the Pocono, can usually be identified by its fissile and carbonaceous or bituminous character as well as by the **Lingula** and **Linguladiscina** that occur in it. After finding this shale the underlying Berea Sandstone can be recognized, if present, by its gray, massive, and often conglomeratic character and by the absence of marine fossils, which, so far as known, do not occur in it.

FOSSIL LIFE, POCONO SERIES.

For nearly 100 years the rocks composing the Pocono Series, as now called, have been studied in Pennsylvania, Maryland, and the two Virginias and have been generally regarded as fresh-water deposits, although marine fossils have

been observed at isolated localities where their occurrence has been looked upon as unusual and where little attempt has been made to trace them into adjacent territory. Dr. I. C. White and C. A. Ashburner recorded three occurrences in Bedford and Huntingdon Counties, Pennsylvania, in the Second Geological Survey of that State; but farther west in Fayette, Westmoreland, and Indiana Counties, Stevenson failed to see them, even describing some of the beds which now prove to be most interesting as "Wholly characterless", and most of the folios of the United States Geological Survey which covered the same ground many years later record no marine fossils, although Butts speaks of a **Lingula** and a fragment of a lamellibranch. In West Virginia a few isolated occurrences were noted by Prof. S. B. Brown, Dr. W. Armstrong Price, and the writer, a short paper having once been prepared for **"Science"** by Dr. Price in which some of these exposures were noted and a few instances having been noted by him in the Tucker County Report of the West Virginia Survey. In general, however, the fossils have escaped attention throughout the State. In Virginia fossils have been found at a few points in the Price (Pocono) Formation but apparently little attempt has been made to utilize them as correlation planes, the statement being made in a quite recent report that no single sandstone bed, with the exception of the basal conglomerate, can be traced from place to place.

After studying the Pocono Series in Mercer and Monroe Counties, West Virginia, and after following the outcrop from its type locality in the Pocono Mountains of Monroe County, Pennsylvania, southwestward across Pennsylvania, Maryland, West Virginia, Virginia, Kentucky, and Tennessee, the writer has found, much to his own confusion as well as to that of his predecessors, that abundant marine fossils exist in various zones of the series all the way from the Broad Top Coal Field of Huntingdon and Bedford Counties, Pennsylvania, westward into Blair, Westmoreland, Fayette, and other counties that border the eastern rim of the Appalachian basin and southward and southwestward across West Virginia by way of Preston, Tucker, Pocahontas, Greenbrier, Monroe, and

Mercer Counties, to the Virginia State line. In the latter State they may also be followed from the coal fields of Montgomery County southwestward into Tennessee through the medium of the Price and Grainger beds and westward into Kentucky where part of the series is known as New Providence and where its fossils have had careful study.

Such parts of the above study as properly pertain to Mercer and Monroe Counties, West Virginia, will be detailed under the "Description of Members" on later pages of this Report but the more extensive studies will be reserved for a subsequent volume on the Mississippian.

Before passing from the subject, however, it is well to note that some of the species found in the lower portions of the Pocono are types which have been regarded as confined almost exclusively to the Chemung Series of the Devonian, so that Dr. Girty has not accepted them as belonging to the Mississippian Period. His viewpoint on some of these collections is quite natural since in many instances he did not see the localities in the field and had no evidence except that of the fossils themselves. In central and northern West Virginia, as well as throughout Pennsylvania, the distinctly red shales of the Catskill Series, varying from a few hundred to several thousand feet in thickness and always being easily recognized, intervene between the Chemung and Pocono, affording a lithologic sequence that can not be disregarded, so that the Pocono Series with its well-known Mississippian flora and its occasional beds of coal can always be identified. Under such conditions the presence of a fauna with certain Chemung aspects in the Pocono must be considered only as a recurrence of these species in younger strata. Such a recurrence need not be surprising, however, since the fauna of the Pocono, as already explained, has had only fragmentary study, and it would appear necessary to abandon the idea that certain types, including **Spirifer disjunctus**, perished before the close of the Devonian.

Plant fossils occur somewhat abundantly in the series, but only a few collections were made for this Report. **Fossil Lot 110 on Map II** was obtained by the writer in a ravine

southeast of the Bluefield water pump station and southwest of Ada, Mercer County, as recorded in the Stony Gap Section, page 199. This lot, consisting of a single loose boulder and therefore not positively identified from a particular horizon, contained a large impression of a fern, the same being forwarded to Dr. David White at Washington. Another collection at a much more northern exposure is as follows:

Local Measurement at Fossil Lot 227.

Irish Corner District, Greenbrier County; in road south of Greenbrier River 2.5 miles southwest of Ronceverte; gentle northwest dip; arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Pocono Series (11′)		
1. Sandstone, very shaly	5	5
2. Shale, gray, very sandy (1800′ B.); contains plant fossils (see **Lot 227**)	3	8
3. Slate, black, **coaly,** to road	3	11

Fossil Lot 227 on Map IV was collected at the above locality by Dr. David White, Mr. Price, and the writer, **Sphenopteris vespertina,** a common Pocono species, being noted on the ground. This collection is now in the hands of Dr. White for further study. Being outside the area where structure was worked in detail its exact horizon was not determined but it is not far from the middle of the series.

In addition to the land plants the Pocono of southern Mercer and southern Monroe Counties contains frequent impressions of the fucoid **Taonurus cauda galli,** a form which is recorded in abundance by Butts in the New Providence Group of Kentucky, and which may be traced eastward through northeastern Tennessee and southwestern Virginia through the medium of the Grainger beds directly into the Pocono at Bluefield. Northeastward the last occurrence of this fossil noted was near Caldwell, Greenbrier County, as recorded in the Caldwell Section, page 233.

CORRELATION, POCONO SERIES.

Through Pennsylvania, Maryland, and West Virginia the rocks that comprise the Pocono Series have fortunately been

generally described under the same title. In the New River Valley of Virginia, however, these rocks have been called the Price Formation and farther southwest in the same State, as well as in northeastern Tennessee, they have been called Grainger, and in some reports have been described as partly of Devonian age, which the writer regards as quite generally contrary to the fact, although there may be instances in that portion of Virginia which lies next to the West Virginia line where some remnants of the Devonian may have been locally mapped as Grainger.

There is also little doubt that the New Providence Group of Kentucky is of the same age as the Pocono, as has already been pointed out by Butts in his discussion of the Mississippian Series of eastern Kentucky, but their basal limits are not the same since the Sunbury Shale and Berea Sandstone belong clearly within the Pocono of Pennsylvania and West Virginia, while in Kentucky they are assigned to groups below the New Providence. It has been generally conceded also that the Pocono includes the Logan Sandstone and Cuyahoga Formation of Ohio. Farther west its relationship to the formations of the Mississippi Valley has often been discussed but an apparently full agreement has not been reached.

DESCRIPTION OF MEMBERS, POCONO SERIES.

LOGAN SANDSTONE.

The **Logan Sandstone** of Andrews[6] appears to form the youngest member of the Pocono throughout those portions of West Virginia where the upper portion of the series is present, and in Pennsylvania this is evidently the Burgoon Sandstone as first so called by Butts[7] in Cambria and other counties. It is also the equivalent of the Big Injun Oil Sand as recorded in thousands of well records in Pennsylvania, West Virginia, Ohio, and portions of Kentucky, but is occasionally

[6]E. B. Andrews, Report Progress. 1869, pp. 62, 76; Ohio Geol. Survey; 1870.

[7]Chas. Butts, Kittanning Folio, No. 115 (1904), and Ebensburg Folio, No. 133 (1905); U. S. Geol. Survey.

PLATE XXVII.—Looking west across Second Creek into Gap Mountain at old mill just north of Gap Mills, Monroe County. Reef is made by White Medina, overturned and now dipping south. Slope at left is Red Medina and pine grove at right covers Clinton, Helderberg, and Oriskany. (Photo. by Palmer & Fowler).

split into two ledges of which the upper and thinner portion has often been called the Keener Sand. Stout and Lamborn[8] of the Ohio Survey, however, attribute the Keener Sand to the Logan and put the Big Injun and Squaw in the Black Hand Conglomerate, or Sandstone, coming just below the Logan. When fully developed the Logan is a gray, coarse, and massive or cross-bedded rock having frequent quartz pebbles. In Mercer County it does not occur, since the upper half of the Pocono is entirely missing at the visible outcrops. In Monroe County it appears to be absent in the southwestern part but in the Gap Mills Section, page 230, it is recorded as gray, shaly, and 238 feet thick, being imperfectly exposed along the road slightly northwest of Red Mill. East and north of this locality it may often be observed. At the extreme northern edge of the county it is noted in the Spider Den School Section, page 227, as 40 feet thick and shaly. In Summers County it does not outcrop but in the Green Sulphur Springs Section, page 241, is exhibited in a well record as 75 feet thick, and in the Warford Section, page 263, another well record shows it to be 128 feet thick, mostly composed of gray sandstone with some quartz pebbles toward the base, and containing a little gas in the top.

The principal economic interest of the Logan Sandstone is its abundant content of oil or gas in many of the more northern and western counties of the State. Naturally it would not contain these products in the region of its outcrop in Mercer and Monroe, and in Summers the prospect of its having oil or gas is not encouraging, but there might be some pockets of gas along some of the anticlines.

Below the Logan Sandstone in eastern Monroe and in Summers County there is usually gray, sandy shale, with a thickness of 50 feet or more, followed below by another sandstone which the drillers record as the Squaw Oil Sand but which apparently has not been named and described at any surface outcrop within this State, and which does not appear to be worthy of naming at any point in the territory of this

[8]Wilber Stout and R. E. Lamborn, Geology of Columbiana County, Geol. Survey of Ohio, Correlation Chart opp. p. 358; 1924.

Report. In Mercer County both the overlying shales and the sandstone are absent along the outcrops and this condition continues across Monroe County to the neighborhood of Red Mill at which locality the series thickens and north of which these portions are doubtless present. In Summers County there is a bed of sandstone nine feet thick and containing a streak of coal, coming 95 feet below the Big Injun Sand and apparently representing the Squaw Sand as noted in the Warford Section, page 263.

Below the Squaw Sand there are sometimes sandy or dark shales to a thickness of 50 feet or more in southeastern Monroe and in Summers County, but in Mercer these shales are never present and in southwestern Monroe they seldom have their full thickness.

MERRIMAC COAL.

The **Merrimac Coal** of Campbell and others[9] is a carbonaceous deposit which occurs in portions of southeastern Monroe County, its interval from the top of the Pocono Series being about 400 feet when the full series is present but often only a few feet along some of the outcrops of Little Mountain. In Mercer County this coal is not present at any outcrop and in Summers it is not recorded in the few available well records.

The type locality of this coal is in Montgomery County, Virginia, where for many years it has been mined under the trade name of the "Big Seam", its character being described as that of a semianthracite with a thickness of 7 or 8 feet in some localities.

In Monroe County there is no great doubt that the upper coal of the Pocono Series along Little Mountain and farther eastward is the same as the Merrimac of Virginia but here it has deteriorated until it is often not more than one foot thick and even when it has reached its approximate maximum of four or five feet it is so slaty and impure that there is no hope that it can be mined for commercial fuel and very little prospect that it can be used locally with any success. At **Coal Ex-**

[9]M. R. Campbell and Others, The Valley Coal Fields of Virginia, Bull. XXV, Virginia Geol. Survey, p. 177; 1925.

posure No. 793 on Map IV, on the east side of a branch of Rich Creek 0.9 mile south of Brick Church, as noted in the Brick Church Section, page 217, there is one foot of slaty coal exposed at the Merrimac horizon, coming 20 feet below the top of the Pocono Series, which is there overturned. At the following prospect an attempt was once made to mine it without much success:

Clarence Symms Prospect—No. 794 on Map IV.

Red Sulphur District, Monroe County; on east side of Rich Creek one mile southeast of Brick Church; **Merrimac Coal;** elevation, 1925′ B.; measurement from north to south in descending stratigraphic order.

		Ft.	In.
1.	Sandstone, massive	..	..
2.	**Coal** 0′ 0″ to	1	6
3.	Sandstone, massive, pavement	..	..

At the above prospect the coal dips southward at an angle of 45 degrees, being sometimes entirely squeezed out between the two sandstones. A sample (No. 617R) was collected, the composition of which is published under **Mine No. 794** in the Table of Coal Analyses near the end of Chapter XIII.

At the following prospect a vigorous attempt was made in the summer of 1922 by some of the citizens of Lindside to determine whether the coal had minable value:

Thomas Long Prospect—No. 795 on Map IV.

Red Sulphur District, Monroe County; on the north slope of Little Mountain 0.9 mile southwest of Lindside; **Merrimac Coal;** elevation, 2445′ B.

		Ft.	In.
1.	Shale, dark-gray	..	..
2.	**Coal** 0′ 10″		
3.	Black smut 0 10	5	8
4.	**Coal,** slaty, semianthracite 4 0		
5.	Shale, dark-gray, with iron pyrites	2	0

The above measurement is in descending stratigraphic order which means that it was measured from the bottom toward the top of the prospect, the dip of the overturned rocks

being now southward at an angle of 25 degrees. This entry was driven about 15 feet in the ground but apparently did not get beyond the zone of surface oxidation, and the section had little uniformity, being different at every point measured along the entry. A sample (No. 615R) was collected from the black smut, No. 3 of section, and another (No. 614R) was secured from the thicker bed of coal, No. 4 of section, the compositions of which are published under **Mine No. 795** in the Table of Coal Analyses near the end of Chapter XIII.

In the same season the **Ernest Fleshman Prospect (No. 796 on Map IV)** was made by the same interests along the east side of Dry Creek 0.6 mile southeast of Lindside as recorded in the Lindside Section, page 218. Here the section of the seam was also quite irregular there being two benches of coal at some points and only one at others, all of which was quite slaty and impure. A sample (No. 629R) was collected from the fresh face about 15 feet under the hill where the thickness of the coal was about two feet, its composition being published under **Mine No. 796** in the Table of Coal Analyses near the end of Chapter XIII.

In the valley of Second Creek the following prospect appears to represent the Merrimac Coal:

Mattie Abbott Prospect—No. 797 on Map IV.

Irish Corner District, Greenbrier County; on the east side of Second Creek 0.7 mile north of Hokes Mill; **Merrimac Coal;** elevation, 1650′ B.

		Ft.	In.
1.	Shale, gray, 5′ 0″ to	10	0
2.	**Coal,** hard, anthracitic fracture	3	0
3.	Shale, black	3	0
4.	Sandstone, shaly, to Second Creek	5	0

At this prospect the coal was once mined and used to a small extent but the place has now fallen shut, a measurement being obtained by cleaning off the outcrop at one side. Here a sample (No. 636R) was collected from the coal, the composition of which is published under **Mine No. 797** in the Table of Coal Analyses near the end of Chapter XIII. The high percentage of ash (75%) would indicate that oxidation at the

surface is almost complete or that the coal is naturally little more than a carbonaceous slate.

In the same region the blossom of this coal occurs in the hill road on the west side of Second Creek 0.2 mile northwest of Hokes Mill, at elevation 1760′ B., being noted as **Coal Exposure No. 798 on Map IV,** and being recorded in the Hokes Mill Section, page 228.

At the **William Foster Prospect (No. 799 on Map IV)** on Carpenter Creek, 1.3 miles east of Second Creek village, at elevation 1980′ B., a considerable amount of work was done by Mr. J. A. Folden, there being a streak of coal 0′ 4″ thick bedded in the middle of a heavy sandstone. This prospect was made primarily in the hope of finding some precious metal and it was reported that a white metal of some sort had been found, but at the time of the writer's visit only a little iron pyrites and some copperas was exposed, although fresh blasts were made to unearth the white material. This prospect may represent the Merrimac Coal.

In the Caldwell Section, page 232, the Merrimac Coal is represented by dark shale with coaly streaks. The following exposure was obtained at one of the southern outcrops:

F. M. Caldwell Prospect—No. 800 on Map IV.

Sweet Springs District, Monroe County; on south side of Turkey Creek, 0.9 mile northwest of McGlone; **Merrimac Coal;** elevation, 2080′ B.; measurement from northwest to southeast in descending stratigraphic order.

		Ft.	In.
Greenbrier Series (..)			
	Limestone, black, with black chert and corals..	..	..
Maccrady Series (170′)			
2.	Concealed	20	0
3.	Shale, red, slickensided	50	0
4.	Shale, variegated, and sandstone	100	0
Pocono Series (65′)			
5.	Slate, black, with coaly streak	15	0
6.	Sandstone, shaly	5	0
7.	Shale and slate, dark	10	0
8.	Sandstone, massive	10	0
9.	**Coal** prospect, **Merrimac,** abandoned, thickness concealed	..	..
10.	Concealed	10	0
11.	Sandstone, gray, massive	15	0
12.	Shale, sandy, and sandstone, interlaminated.	..	..

At this locality the rocks are quite irregular, the average dip of the overturned beds being southeastward at an angle of 45 degrees. Mr. Caldwell says that he burned this coal in his blacksmith shop but that it clinkered badly. The fragments left on the dump appear to be very slaty, with a conchoidal fracture.

Farther northeast the following exposure was observed:

Coal Exposure—No. 801 on Map IV.

Sweet Springs District, Monroe County; in road on south side of Cove Mountain 0.5 mile north of Pedro; **Merrimac Coal;** elevation, 2540′ B.

		Ft.	In.
1.	Sandstone, massive, coarse, soft.....	20	0
2.	**Coal,** soft, slaty..... 0′ 3″		
3.	Shale, dark-gray..... 0 5	 1	6
4.	**Coal,** soft, rotten, with bituminous fracture. 0 10		
5.	Sandstone, gray, shaly, (dip, North 20°)...	20	0

A sample (No. 609R) was collected from No. 4 of section, the composition of which is published under **Mine No. 801** in the Table of Coal Analyses near the end of Chapter XIII.

A study of the analyses of the Merrimac Coal as published in the Table of Coal Analyses together with the detailed exposures and prospects herein exhibited shows that little hope of finding valuable coal in this horizon can be entertained in Monroe County. The coal is so irregular, slaty, and impure, as well as so much distorted by the lateral pressure which overturned the strata, that it could hardly be seriously considered as a commercial deposit, and it is quite doubtful whether attempts to use it for local domestic use will ever be successful.

LINDSIDE SANDSTONE.

The **Lindside Sandstone** (new), coming almost immediately below the Merrimac Coal and occupying most of the interval between this seam and the Langhorne Coal, is a greenish-gray or reddish-brown and sometimes ferruginous bed having a thickness that varies from a few feet up to 40 or

50 feet. Its type locality is in Monroe County on Dry Creek about 0.6 mile southeast of Lindside and just south of the **Ernest Fleshman Coal Prospect (No. 796 on Map IV)** as exhibited in the Lindside Section, page 218. Here it is partly greenish, partly reddish-brown, ferruginous and 50 feet thick, being rather poorly exposed in the creek bluff and being overturned along with the other strata of Little Mountain.

In southwestern Monroe west of Lindside, and in the Pocono outcrop across southern Mercer, this sandstone is absent along with all other overlying members of the series. In the Gap Mills Section of Monroe County, page 230, its horizon is almost if not entirely concealed, there being an interval of 250 feet between the Logan and Broad Ford Sandstones in which the strata are too poorly exposed for identification. In the Caldwell Section, page 232, which is in the edge of Greenbrier County, just outside of Monroe, it is represented by a green, but very sandy shale, 15 feet thick, which might almost pass for a sandstone. In Summers County it does not outcrop and was not distinguished in the few wells that have been drilled through its horizon.

In external territory its extent northeastward across West Virginia has not been fully determined, but with some exceptions the series thickens in that direction toward Maryland and Pennsylvania, in which latter State especially there are many heavy sandstones in the Pocono, and the Lindside is doubtless represented although its recognition will not be easy. In Virginia it is visible and easily identified in the gap of Poverty Creek, Montgomery County, where both the Merrimac and Langhorne Coals have been opened and locally mined.

LANGHORNE COAL.

The **Langhorne Coal** of Campbell and others[20], belonging 20 to 50 feet below the Merrimac Coal and almost immediately under the Lindside Sandstone, is a thin and impure bed that

[20]Ibid, p. 145.

may be noted at a few localities in Monroe County. At **Coal Exposure No. 802 on Map IV,** on the east side of Dry Creek 0.7 mile southeast of Lindside, it is represented by one foot of coaly shale, as recorded in the Lindside Section, page 218. In the Caldwell Section, page 233, it is noted as a dark, carbonaceous shale, the exposure being in the edge of Greenbrier County. In southwestern Monroe west of Lindside and in the outcrops of southern Mercer its horizon appears to be almost wholly absent along with other overlying members of the Pocono. In Summers County it was not noted in the few wells of which records are available. There appears to be no hope of finding good coal at this horizon in the three counties, but its occasional presence is of much scientific interest and value in the correlation of the Pocono Series.

BROAD FORD SANDSTONE.

The **Broad Ford Sandstone** (new), belonging only a few feet below the Langhorne Coal and slightly below the middle of the Pocono Series, is a reddish-brown, or occasionally greenish-gray or rusty ledge, varying in thickness from 50 to 300 feet and often containing abundant marine fossils together with occasional fucoids. Its type locality is at the line between Smyth and Tazewell Counties, Virginia, about one-half mile north of Broad Ford village, where Laurel Creek of Holston River cuts a gap through the ridge known as Pine Mountain on the west and Brushy Mountain on the east. Here the visible Pocono is 765 feet thick with a southeastward dip of 30 degrees, the Maccrady being exposed on the south near the edge of the village while at the north end of the gap the Chemung is imperfectly exhibited so that the Pocono-Chemung contact is not quite clear on account of debris. The stratum herein designated as Broad Ford outcrops just north of the point where the public road fords the creek, its top being 230 feet below the base of the Maccrady Series and its thickness being 335 feet, of which there is an upper bench of 40 feet of reddish-brown and thick-bedded sandstone, containing marine fossils on its upper surface among which brachiopods (**Syringothyris**, etc.) and crinoids were noted, and also having the

fucoid **Taonurus cauda galli.** Beneath this ledge there is a partly concealed interval of 30 feet in which a similar sandstone is partly visible, followed below by 265 feet of solid reddish-brown, thick-bedded, medium fine-grained and very hard sandstone which makes an immense reef in the mountain just north of the mill dam. Below and north of this ledge there appear to be about 200 feet of largely concealed but presumably Pocono beds before typical Chemung shales and fossils may be observed.

In Montgomery County, Virginia, 60 or 70 miles east of Broad Ford, the stratigraphic position of the Broad Ford Sandstone is even better exhibited than at the type locality, there being an exposure in the gap of Poverty Creek about 2½ miles northwest of Prices Forks where the ledge is visible 70 feet below the Langhorne Coal, and is 230 feet thick, with marine fossils, among which brachiopods (**Chonetes**, etc.), gastropods, and crinoids were noted in the lower part, as first collected by the writer and as later amplified by further collections by Prof. R. J. Holden, of Blacksburg, Virginia. In this gap the base of the sandstone is 300 feet above the base of the Pocono Series, which is there very distinct, and its top is 498 feet below the top of the Pocono which is also quite plain.

The Broad Ford locality, although entirely outside of the territory of this Report, has been selected as typical of this sandstone because it is apparently the most spectacular occurrence of the ledge, and the locality on Poverty Creek is also mentioned because the relationship of the sandstone to the two principal coals of the Pocono, as well as to the top and base of the series, is very plainly evident; and the further fact that marine fossils occur near its base on Poverty Creek is worthy of comment, since it does not appear that they are confined to any particular zone but may often be noted at various levels when the rock becomes slightly ferruginous or shaly.

In Mercer County, West Virginia, the Broad Ford Sandstone is usually at or near the top of the Pocono Series, the overlying coals and sandstones being entirely absent. In

Bluefield it was formerly exposed in the excavation for the Bailey Building just opposite the Post-Office and in adjacent territory, being about 300 feet thick but split into two or three benches by shales, although it still retains in large part its characteristic reddish-brown color and carries marine fossils almost all the way from top to bottom, as recorded in the Bluefield Section, page 194. **Fossil Lot 2 on Map II** was collected in the excavation of the Bailey Building by Dr. Prouty and the writer, and according to Dr. Prouty contained **Camarotoechia** sp. and **Fenestella** (several species). Later the writer observed crinoids, gastropods, and other brachiopods (**Chonetes**) in a more thorough inspection of the locality. North of the Bailey excavation the fucoid **Taonurus cauda galli** is present and farther north toward the top there are also brachiopods, crinoids, and fucoids, illustrating quite well the evident range of fossils throughout the member. The sandstone is quite inconspicuous, however, being much weathered out and now almost covered by new buildings.

In the Stony Gap Section, page 199, it is visible on a branch of East River southeast of the Bluefield water pump station and southwest of Ada, being there mostly reddish-brown, thick-bedded and hard and 218 feet thick. Here it appears to contain both plant and marine fossils. **Fossil Lot 110 on Map II,** consisting of a loose boulder containing the large impression of a fern and apparently coming from this horizon, was collected by the writer and forwarded to Dr. David White. **Fossil Lot 294 on Map II** was collected by the writer from the marine invertebrates near the base of the member and was sent to Dr. Girty, there being crinoids, brachiopods (**Chonetes,** etc.), and a long gastropod, or possibly a cephalopod, which was too indistinct for more particular determination in the field.

In the edge of Giles County, Virginia, the Broad Ford Sandstone is visible in the cut of the Norfolk and Western Railway on the west side of New River, as recorded in the Lurich Section, page 205, being 108 feet thick, reddish-brown and coarse at the top but shaly at the base, and containing marine fossils including brachiopods, bryozoa, and pelecypods,

as collected by Dr. Prouty and the writer at **Fossil Lot 15 on Map IV** and as specified by the former in the Lurich Section.

In southwestern Monroe County the Broad Ford Sandstone apparently continues to make the top of the Pocono for several miles but on the waters of Rich Creek west of Lindside some younger beds appear above it, as previously mentioned, and thence increase in thickness eastward. In the Brick Church Section, page 217, it is 255 feet thick, as exposed on Rich Creek southeast of Brick Church, but is divided by beds of sandy shale or is partly concealed so that its outcrop is inconspicuous. **Fossil Lot 297 on Map IV** was collected by the writer from the upper 10 feet of the member, there being crinoids and brachiopods (**Chonetes, Productus,** etc.), and fragments of plant fossils which appear to be fucoids. This lot was forwarded to Dr. Girty. Farther down there are crinoids and other marine fossil fragments and the fucoid **Taonurus cauda galli.**

In the Lindside Section, page 218, the Broad Ford Sandstone is reddish-brown and thick-bedded but partly concealed, its total thickness being about 200 feet and its exposure being just beneath the Langhorne Coal. In the Gap Mills Section, page 230, farther east, it is gray in color and partly massive and partly shaly, with a thickness of 160 feet, but the exposure is quite poor and no fossils were observed. Here it appears to come nearly 500 feet below the top of the Pocono in harmony with the reappearance of the upper part of the series in that part of the county. In the Caldwell Section, page 233, which is in the edge of Greenbrier County, the sandstone is only 75 feet thick but is quite conspicuous both along the Chesapeake and Ohio Railway and along the State road (Midland Trail), being green on fresh fracture but weathering brown and having the fucoid **Taonurus cauda galli** which was not observed at other localities farther northeast in the Appalachian region. In the Hokes Mill Section, page 228, it is recorded as a gray, massive ledge, 70 feet thick, as exposed along Second Creek in the edge of Greenbrier County just north of the Monroe line.

In Summers County, a portion of it appears to be present

in the Warford Section, page 263, where it is named as the Weir Sand, coming 90 feet above the top of the Berea.

In its more extended relationships in other States the Broad Ford Sandstone is perhaps the most dependable member for correlation purposes in the whole Pocono Series, partly because of its color, which is not by any means constant but which in many localities is quite the same as at Broad Ford, and which is very distinctive when so found because few if any other sandstones of the Pocono are red, and partly because of its assemblage of marine fossils which have a wide territorial extent. Southwest of Bluefield it may be traced across Virginia into Kentucky and far into northeastern Tennessee, where it makes a part of the so-called Grainger beds, its outcrop being usually quite shaly and crumbly but often red and marked by the occurrence of **Syringothyris** and other marine fossils as well as by **Taonurus cauda galli.** It is not to be assumed that the color of the sandstone or any of the fossils named in it are diagnostic, but the combined lithology, fauna, and flora do not appear to be duplicated elsewhere in the Pocono or any other series.

Northeast of Monroe County the sandstone may be followed across West Virginia, having abundant marine fossils at Marlinton, Pocahontas County, and Rowlesburg, Preston County, and then extending northward into Pennsylvania where it is generally fossiliferous in the deep valleys of the Youghiogheny and Conemaugh Rivers when brought to the surface by the uplifts of the Chestnut Ridge and Laurel Ridge in Fayette, Indiana, and other counties. Farther northeast it appears to lose its fossils but is represented partly by red shale and red sandstone in the Broad Top coal field and in the gaps of the Susquehanna River north of Harrisburg. Still farther northeast in the Pocono Mountains of Monroe County there is a reddish-brown sandstone, capping the ridge east of Gouldsboro Lake, which belongs at the approximate position of the Broad Ford Sandstone of Virginia and which can scarcely be distinguished from it in physical character. This resemblance is so remarkable and so different from all other Pocono sandstones that a correlation between these two very

distant regions is immediately suggested although not proved.

In this connection, however, it is well to remark that in northern West Virginia and on the Youghiogheny and Conemaugh Rivers of Pennsylvania where the Broad Ford Sandstone becomes quite shaly, the faunas of this and other members of the lower part of the Pocono assume certain aspects which Dr. Girty considers to be of a Devonian character, based on his study of the collections made by the writer at these localities. The stratigraphy, however, can scarcely be reconciled with the Chemung Series of the Devonian, with which the fossils to some extent correspond, there being at all these points a heavy deposit of red Catskill shale coming between the base of the Pocono and the top of the true Chemung. In the opinion of the writer the recurrence of a supposed Chemung fauna in the Pocono of this region is to be explained by an upward range of these fossils which has hitherto been unknown, since collections have previously been made in scarcely any of these beds.

The Broad Ford Sandstone appears to occupy a quite similar stratigraphic position to that of the Weir oil sand of Kanawha County, West Virginia, which is probably a thin representative of this ledge. It also appears to belong at nearly the same horizon as the Purslane Sandstone of Morgan County, West Virginia, and the Pawpaw-Hancock area in general, although there is no physical resemblance. The possibility of its correlation with that stratum is suggested as worthy of further study but is not affirmed.

Beneath the Broad Ford Sandstone there are occasional greenish-gray or sandy shales with streaks of sandstone, filling an interval that is often less than 25 feet but that sometimes reaches 100 feet or more in the three counties. Owing to the uncertain and somewhat lenticular nature of these deposits they do not appear worthy of detailed classification in the territory under study.

SUNBURY SHALE.

The **Sunbury Shale** of Hicks[11], named from its occurrence

[11]L. E. Hicks, Am. Jour. Sci., 3rd Ser. Vol. XVI, pp. 216, 220; 1878.

near Sunbury, Delaware County, in central Ohio, appears to comprise an integral part of the West Virginia and Pennsylvania Pocono as limited by most authors. In Ohio it is classified as a formation of the Waverly Group, its position being between the overlying Cuyahoga and the underlying Berea, while in Kentucky it is described in the same position, the overlying beds being called Cuyahoga by some authors and New Providence by others, and the Berea being named below it as in Ohio. In West Virginia as well as in portions of western Pennsylvania, the presence of a black or brown shale above the Berea Sandstone has for many years been well known to the oil well drillers of those two States, the usual title for it being the "Coffee Shale". In many wells it has been carefully noted since it is the only distinctly black or brown shale that is often encountered in the Pocono Series and when found is an excellent marker for the Berea Sandstone which often contains oil or gas. Strangely enough its surface outcrop has never been studied in West Virginia and its local characteristics have therefore been only vaguely known through the medium of well records.

In southern West Virginia the Sunbury Shale is a black, fissile, and carbonaceous, or more rarely a greenish-gray and sandy deposit, varying in thickness from 25 to 50 feet and containing marine fossils among which **Lingula** and discinoids are common forms. Specific determinations have now been reported by Dr. Girty on one of the local collections and at one point Dr. Prouty has identified **Lingula melie,** and in Kentucky Butts is authority for the statement that the Sunbury commonly holds **Lingula melie** and **Orbiculoidea herzeri.** The writer, has, therefore, indicated in the general section of the Pocono the positive presence of the former species and of **Linguladiscina herzeri** which may be the same as the latter Kentucky form named. The shale also contains plant fossils, a species of what appears to be **Calamites** having been noted by the writer in the edge of Tazewell County, Virginia. The top of the Sunbury in these southern counties varies from 25 to 100 feet or more below the Broad Ford Sandstone, while its base is just above the Berea Sandstone.

Dr. Girty has under study the collection made from this shale by the writer but as yet has not agreed that its correlation may be assumed as positive on paleontologic evidence, his attitude as expressed in letters and informal discussion being that the **Lingula** and **Linguladiscina** found in it are too common to be regarded as finally diagnostic. The writer, in forming an independent opinion, recognizes the weight of Dr. Girty's caution but at the same time considers that the stratigraphic evidence in this case is so overwhelming that the correlation might be safely made even if no fossils of any kind were found in the shale, while at the same time their presence is highly assuring that no mistake has been made since **Lingula melie** has been almost universally recognized in the Sunbury throughout Ohio and Kentucky.

In Mercer County the Sunbury Shale is visible in Bluefield on the eastern side of Bland Street about 800 feet south of the Post-Office, where it is dark, argillaceous, and carbonaceous, 20 feet thick, and occurs 200 feet below the base of the Broad Ford Sandstone and just above the top of green shales containing Chemung fossils as recorded in the Bluefield Section, page 194. **Fossil Lot 296 on Map II** was collected by the writer from the Sunbury at this point and was forwarded to Dr. Girty. Both **Lingula malie** and **Linguladiscina herzeri** are reported by him.

In the edge of Tazewell County, Virginia, the following local measurement was obtained by Dr. Prouty and the writer:

Local Measurement at Fossil Lot 13.

Tazewell County, Virginia; in street along east side of Beaver Pond Creek at southern end of Bluefield, Virginia (Graham): traverse north to south across overturned strata; actual dip, southeastward 70°; arranged in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Pocono Series (15′)		
1. Shale, green, sandy	..	..
2. **Shale, Sunbury,** black, fissile, with **Lingula**	15	15
Chemung Series (75′)		
3. Sandstone and shale, olive-green, with marine fossils (2415′ B.)	75	90
Lot 13 from Nos. 2 and 3; contains **Spirifer disjunctus** Sowerby, **Camarotoechia sappho** Hall; **Lingula melie** Hall.		
4. Shale and sandstone, greenish-gray, no fossils observed	..	..

At the above locality **Fossil Lot 13 on Map II** was collected, but as indicated by the section is partly in the Pocono and partly in the Chemung Series, the contact not being recognized at the time the work was done, although the presence of a black shale containing **Lingula** was remarked. This collection was studied by Dr. Prouty whose identifications show the presence of a species that is common in the Sunbury. It is evident both at Bluefield and at Graham that no Berea Sandstone is locally present.

In the Stony Gap Section, the Sunbury was not noted in the imperfect exposure of the Pocono in that locality, but in the edge of Giles County it is visible in the cut of the Norfolk and Western Railway on the west side of New River southwest of Rich Creek as indicated in the Lurich Section, page 205, being brown, sandy, fissile, and 65 feet thick, and coming directly beneath the Broad Ford Sandstone but separated from the underlying Berea, which is there present, by 45 feet of interlaminated shale and sandstone which may belong to the Berea or perhaps to the Sunbury itself. No fossils were noted but the exposure was not carefully studied.

In southern Monroe County, both in the Brick Church Section and the Lindside Section, the Pocono is terminated at the base by the Broad Ford Sandstone, but in the Gap Mills Section, page 230, there is an interval of 220 feet between the Broad Ford Sandstone and the base of the Pocono which is occupied by sandy shale with a little sandstone but which, unfortunately, was not carefully studied. In the Caldwell Section, page 233, located in the edge of Greenbrier County, the interval of 150 feet between the Broad Ford and Berea Sandstones is partly occupied by shale which appears to be Sunbury.

In Summers County the position of the Sunbury Shale is clearly shown in a well record published in connection with the Warford Section, page 263, there being 20 feet of dark-gray, sandy beds just above the Berea Sand and other dark shales slightly higher that may also belong with it.

In external territory the Sunbury Shale may be identified at certain points northeastward across West Virginia, being

PLATE XXVIII.—View from one mile east of Gap Mills, Monroe County, looking west through valleys of Kitchen and Back Creeks, Gap Mills High School being visible in middle with village showing faintly to right of school. Wooded ridges at right are part of Gap Mountain with core of overturned White Medina followed by Red Medina which is faulted against Beekmantown Limestone which makes rolling land in middle, its chert fragments being visible. Ridge in left rear is Peters Mountain capped by White Medina. (Photo. by Palmer & Fowler).

visible in the cut of the Baltimore and Ohio Railroad west of Rowlesburg, Preston County, where it contains **Orbiculoidea** and other fossils.

In Pennsylvania it may be recognized with certainty in Fayette County but farther northeastward its existence is still in doubt. In Virginia it may be followed with ease southwestward for many miles, but in the vicinity of Cumberland Gap the Chemung and other green shales of the Devonian which separate the black beds of the Mississippian from those of the Devonian farther northeastward, have entirely disappeared. From this region westward into Kentucky and southwestward across Tennessee a black shale persists but geologists do not agree as to its correlation, the deposit being considered by some as wholly Devonian, by others as entirely Mississippian, and by still others as partly Mississippian and partly Devonian with a postulated disappearance of all intervening green shales. The writer has measured many sections throughout this territory but prefers to refrain from an expression of opinion until these sections can be fully presented in another volume. This problem in southwestern Virginia, Kentucky, and Tennessee does not seriously affect the correlation of the Sunbury Shale in West Virginia, since in the latter State it is separated from the black Devonian shales by a large interval of intermediate strata.

BEREA SANDSTONE.

The **Berea Sandstone,** or **Berea Grit,** of Newberry[12] has been almost universally recognized as the base of the Pocono Series, and therefore as the beginning of the Mississippian Period of deposition, in West Virginia, although this is not the case in portions of southwestern Virginia, Kentucky, and Ohio, where the Bedford and other earlier Mississippian shales sometimes occur beneath it. In West Virginia, with the possible exception of the isolated deposits of Morgan County where the identification of the Berea is still in doubt, and farther northeastward in the Appalachians, there appears to

[12]J. S. Newberry, Report Progress, 1869, pp. 21, 22, 29, Ohio Geol. Survey; 1870.

be little or no trace of any Mississippian formation older than the Berea.

In the outcrops of Mercer and Monroe Counties the Berea Sandstone is usually gray, massive, coarse, and hard, although sometimes cross-bedded or shaly, and frequently carries numerous quartz pebbles, its thickness when present varying from 25 to 150 feet. So far as known it does not have marine fossils, its character in this respect being distinctive, since it rests directly upon the fossiliferous shales and flagstones of the Chemung Series, there being no intervening Catskill in this southern region.

In Mercer it was not observed at any of the more western outcrops, but it may be present along the eastern edge, since it is visible in the edge of Giles County, Virginia, on the west side of New River southwest of Rich Creek, as indicated in the Lurich Section, page 205, there being 15 feet of coarse and quartzitic sandstone, followed below by 65 feet of brown shale and sandstone which should perhaps also be classed with it.

In the western part of Monroe County it is also absent, but in the Gap Mills Section, page 230, the lower part of the Pocono below the Broad Ford Sandstone consists of 220 feet of sandy shales and sandstone, the basal portion of which must represent the Berea, although the exposures are too indistinct for differentiation. Farther north in the Second Creek drainage of this county there are heavy sandstones in the basal Pocono, causing the presence of the Berea to be inferred, but the exposures were not sufficiently studied to make its identification positive. In the Caldwell Section, page 233, located in the edge of Greenbrier County, it is 75 feet thick, flaggy and shaly at the top but thick-bedded and greenish-brown toward the base, and having some sandy shale below it which probably also belongs to it, but which may be Chemung.

In Summers County it is noted in the Green Sulphur Springs Section, page 241, being 25 feet thick and white, as recorded in a deep well. In the Warford Section, page 263, it is reported in another well record as 130 feet thick and

mostly composed of gray or white sandstone with a little dark slate.

In the outcrops of the Pocono northeastward across other counties in West Virginia the Berea may be noted at various localities, its character being much the same as in Monroe County, and still farther northeast in Pennsylvania the base of the Pocono is often composed of an immense, gray conglomerate, highly suggestive of the Berea although its correlation as such may be difficult of proof.

In Montgomery County, Virginia, the base of the Price (Pocono) Formation is made by a conspicuous white, quartz conglomerate described as the "Ingles Conglomerate" by Campbell and others[13], the identity of which with the Berea Sandstone is not much in doubt, since it occurs just over the fossiliferous Chemung and only about 200 feet below the Broad Ford Sandstone. The same sandstone is 100 feet thick, with quartz pebbles and with impressions of tree trunks, at the base of the Pocono in the cut of the Chesapeake and Ohio Railway just east of Alleghany Station, Alleghany County, Virginia, being a link in the chain of evidence between Montgomery County, Virginia, and Monroe County, West Virginia.

In southwest Virginia west of Bluefield the Berea is absent at some outcrops but appears to be present at Pennington Gap and possibly also at Cumberland Gap. Its presence in Kentucky, also, has been described by other authors.

ECONOMIC ASPECTS, POCONO SERIES.

The presence of coal in the Pocono Series of Monroe County has already been noted, with the statement that these beds do not appear to be of appreciable economic value; and so far as known they do not occur in Mercer and Summers Counties. Its shales are usually too sandy for making brick and its sandstones in Mercer and Monroe Counties are generally too much cross-bedded or streaked with shales for successful use as building stone, except perhaps in the northeastern part of Monroe County, where some of the ledges

[13]M. R. Campbell and Others, The Valley Coal Fields of Virginia, Bull. XXV, Va. Geol. Survey pp. 26-28: 1925

could be used for heavy masonry if so desired. Farther north in the State the sandstones of this series often hold abundant quantities of oil and gas, for which they are excellent reservoirs because of their porosity. In southern Mercer and southern Monroe Counties, where the Pocono outcrops, there can be no hope of finding such products, but it is possible that a little gas may be eventually found in Summers County and the adjoining portions of Mercer and Monroe, although the wells already drilled have been failures.

CHAPTER X.

STRATIGRAPHY—DEVONIAN ROCKS.

INTRODUCTION.

The rocks of the Devonian Period in the territiory under study represent an intermediate phase of their Appalachian outcrops, being much more poorly developed than in the northeastern counties of West Virginia and in Maryland, Pennsylvania, and New York. At the same time they are much more prominent than in the more southern States where these beds dwindle away and almost, if not entirely, disappear. The thickness of their combined series or groups does not seem to exceed 4,300 feet, even when the maximum occurrences are totalled, and it is probable that 3,500 feet would be a generous figure for any particular locality. In comparison with the approximate total of 11,000 feet in the Potomac region of West Virginia and with even larger figures for eastern Pennsylvania, it is evident that little more than one-fourth of the more northern beds remain. One whole series is entirely absent and probably never was deposited, while all the others are deficient in thickness, possibly on account of erosion in part but more likely because of abbreviated sedimentation. There is good reason to believe that the poverty of Devonian beds in this region is largely responsible for the exceptional development of the overlying Mississippian, since the natural tendency in a succeeding epoch would be toward filling the void that must have existed in the local Appalachian sea at the end of Devonian time.

In part of this area the rocks have been previously studied

by Campbell[1] who classified the Devonian beds as follows:

	Feet.
Kimberling Shale	3,000 to 3,250
Romney Shale	400 to 600
Giles Formation (partly Silurian)	30 to 200

The above subdivision in which portions of several groups or series were included in a single formation may have been justified in view of the early date at which these beds were studied, and in consideration of the wooded and generally unfavorable conditions which then prevailed in some of the basins in Virginia where the major portion of the Devonian of this folio occurred. At the present time and in the territory herein mapped there is no good reason why a more detailed subdivision should not be made nor why the standard column of New York should not be recognized, since the exposures show most of the data necessary for their identification. Adhering to this rule and including the tripartite division that has generally been favored in recent years, the Devonian of these counties has the following succession in descending order:

Upper Devonian:
- **Chemung Series (500-1600′)**
  - Shales and sandstones (including Hendricks)
  - Upper (Lackawaxen) Conglomerate
  - Shales and sandstones
- **Portage Series (400-1600′)**
- **Genesee Series (50-100′)**

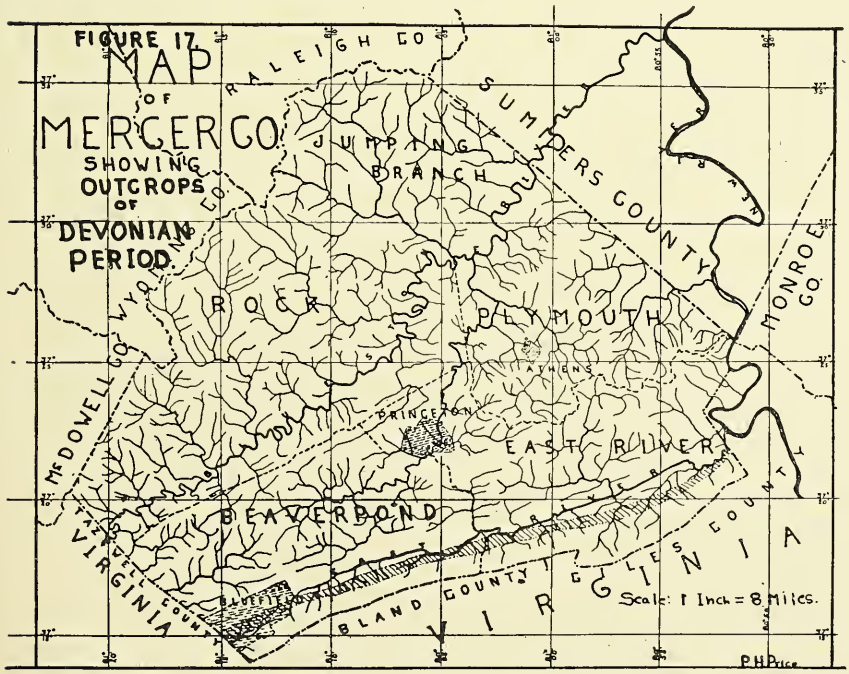
Middle Devonian:
- **Hamilton Series (0—500′)**
- **Marcellus Series (100-300′)**
  - Shales
  - Lower Selinsgrove Limestone
  - Selinsgrove Shale

Lower Devonian:
- **Oriskany Series (50-150′)**
  - Mostly Ridgeley Sandstone
- **Helderberg Limestone (0—50′)**
  - Mostly New Scotland Chert.

Compared with the Devonian column of the Potomac region of northeastern West Virginia as lately published by the

[1]M. R. Campell, Pocahontas Folio, No. 26, U. S. Geol. Survey; 1896.

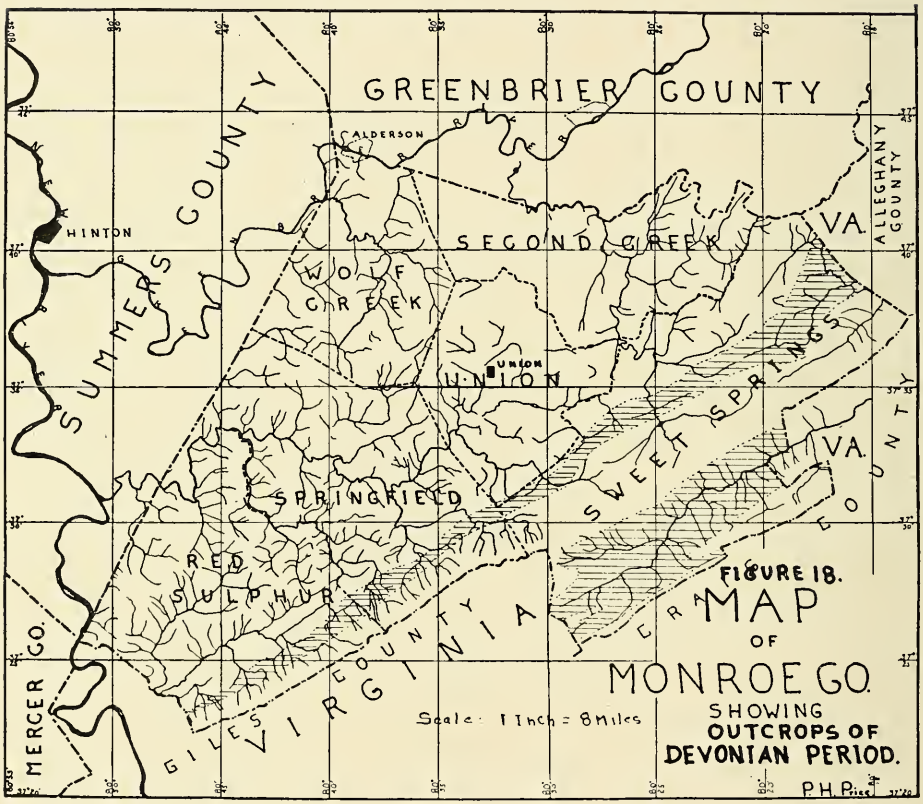
Survey[2] it is evident that the Catskill Series, which in Mineral County has a thickness of 2400 feet and which makes the upper portion of the period all over northeastern West Virginia and other States lying beyond, has entirely disappeared in Mercer and Monroe. The Helderberg Limestone, belonging at the base of the period, is also largely absent, there being usually less than 50 feet of its cherty New Scotland member, as compared to a maximum of 600 feet for the entire Helderberg in the Mineral and Grant area where at least three of its important subdivisions are well represented. The series which intervene between the Catskill and Helderberg are likewise considerably abbreviated, some of their important subdivisions being absent and others much attenuated. Erosion may partly account for these losses but it is more probable that deficiency of sedimentation is the principal cause.



Figures 17 and 18, prepared by Mr. Price, respectively

[2]David B. Reger, Mineral and Grant Report, W. Va. Geol. Survey, p. 286; 1924.

show the outcrops of the Devonian in Mercer and Monroe Counties, and Maps II and IV show the same data on a much enlarged scale.



UPPER DEVONIAN ROCKS.

CHEMUNG SERIES.

GENERAL ACCOUNT, CHEMUNG SERIES.

The Chemung Series of the Upper Devonian, belonging normally just below the Catskill of the same major division but in Mercer and Monroe occupying a position just under

the Pocono Series of the Mississippian, is a mass of interbedded flagstones and shales of marine origin, having a thickness which varies from 500 to 1600 feet. The flags usually range in thickness from one to six or eight inches, and are greenish-gray or olive-brown, fine-grained, and often quite hard and compact but sometimes inclined to be shaly. In some instances these flags combine into a single ledge 10 to 15 feet in thickness, but such a condition appears to be largely local. The shales, with few exceptions, are olive-green or greenish-gray in color, being mostly fissile but occasionally weathering into pencil strips a few inches long. Pure limestone is entirely absent but there are a few streaks of fossiliferous material that have enough iron to become quite brown on exposure and apparently enough calcareous matter to cause conchoidal weathering.

Evidence of littoral conditions is common, there being abundant ripple-marks and occasional conglomerates. Of the latter there are two distinct ledges along the Monroe-Greenbrier County line, as exhibited in the Caldwell Section, page 233, both of which occur in the upper part of the series, while in western Monroe and in Mercer these appear to be absent. The matrix of both is quite similar to other Chemung sandstones with the exception of being more massive, while their pebbles are usually of white quartz, oblong and much flattened in shape and generally arranged in thin belts parallel to the bedding-planes. The size of some is only that of a small bean while others have lengths of two inches or more. Some remarks on the correlation of these conglomerates will later appear.

In the Bluefield Section, page 194, the Chemung and Portage are together only about 950 feet thick; in the Blake Section, page 201, the recorded thickness of the Chemung is 542 feet but its base was not certainly recognized; in the Lurich Section, page 205, it is only 95 feet, being almost entirely absent; in the Gap Mills Section, page 230, its total is 1537 feet; in the Caldwell Section, page 233, the portion examined totals 425 feet but this is only the upper part.

SUBDIVISIONS, CHEMUNG SERIES.

As discussed at some length in the Mineral and Grant Report, Dr. I. C. White and Dr. John J. Stevenson, who studied the Chemung extensively in Pennsylvania and elsewhere southeastward, usually divided it into five parts, as follows:

Shales and sandstones
Upper (Lackawaxen) Conglomerate
Shales and sandstones
Lower (Allegrippus) Conglomerate
Shales and sandstones.

In the Upper Devonian Volume of the Maryland Survey Dr. Charles K. Swartz and his associates recognize the same approximate subdivisions but do not entirely agree that the two conglomerates of Maryland may be classified with the Lackawaxen and Allegrippus. They also introduce some further lithologic refinements and indicate definite faunal zones.

In Mercer and Monroe Counties it is evident from the Devonian column, as published on page 131 of this Report, that the Lower (Allegrippus) Conglomerate and the shales and sandstones which belong beneath it have not been recognized. These do not appear to be present at all in Mercer nor in the western part of Monroe, but their absence is not so certain in the northeastern corner of the latter county, since the series greatly thickens in that direction. No conglomerate was observed in the lower part of the series in that region, however, so that the presence of these lower divisions of the series is not regarded as probable.

The Hendricks Sandstone, belonging in the upper subdivision, has been identified in eastern Monroe, both by its position and by its fauna, as will be later described.

In the Caldwell Section, page 233, the subdivisions of the upper portion of the Chemung are very well displayed, including the Hendricks Sandstone and Lackawaxen Conglomerate, but the section, unfortunately, was not continued to the base of the series, being measured only to the base of a second con-

glomerate which comes 50 feet below the Lackawaxen. It is not now known whether this underlying bed is merely a local deposit or whether it should have a definite place in the Chemung stratigraphy of Greenbrier and other southern counties. In view of the poor development of the series in Mercer and Monroe it has not, in general, appeared worth while to study its characteristics in much detail, since there are much better and thicker exposures in Greenbrier which lies just to the northeastward.

TOPOGRAPHIC EXPRESSION, CHEMUNG SERIES.

The Chemung Series, as a rule, makes sharp ridge lines, smooth slopes which are straight in profile without being noticeably convex or concave toward the mountain, and norrow V-shaped valleys. In Mercer and Monroe Counties these general characteristics are not so apparent, since the outcrops of the series are narrow and confined to regions where there has been much structural disturbance, so that favorable opportunity to observe the topographic features of the series entirely free from external influences is not afforded. In the regions of its outcrops it invariably occurs in sharp ridges and narrow valleys without much noticeable benching of the hills.

AREAL EXTENT, CHEMUNG SERIES.

In Mercer County the outcrop of the Chemung starts at the Virginia State line at the southern edge of Graham (now Bluefield, Virginia), passes northeastward through Bluefield, West Virginia, being in the southern slope of the sharp ridge which divides the business part of the city from South Bluefield, extends generally northeastward with the extension of this ridge on the south side of East River as indicated on Map II, except that in the vicinity of Blake the river bends southward into the Portage outcrop and finally reaches the line of Giles County, Virginia, about one mile south of Glenlyn. In all this distance across the county the beds are overturned and now dipping sharply southward, the outcrop being seldom more than one-fourth or one-third mile wide.

The outcrop then passes for five miles across the northern end of Giles County, Virginia, being exposed on both sides of the narrows of New River about three-fourths mile south of Rich Creek Station but being poorly developed. As shown by Map IV it enters Monroe County slightly less than 1½ miles southeast of Peterstown and continues northeastward mainly with the southern slope of Little Mountain for many miles, being still overturned and highly inclined but gradually thickening. On Second Creek south of Red Mill, where the beds are vertical or only slightly overturned, it passes into Middle Mountain and the belt widens so that it includes not only the southern slope of this ridge but also Wolf Hills and Nigger Mountain and the beds are no longer overturned although still much inclined. Just east of Cove Creek it passes into Alleghany County, Virginia, the width of the outcrop in this locality being nearly 2½ miles.

Farther north in the same county a solid area of 15 or 20 square miles appears to be wholly occupied by the Chemung, including most of the drainage of Laurel Creek with the summit and northern slope of Cove Mountain, all of Brushy Mountain and part of Daniels Ridge. In this latter territory the beds are not overturned but there are many local reversals of dip and much slumping so that a good opportunity for their study is not afforded.

CONTACTS, CHEMUNG SERIES.

The upper boundary of the Chemung with the Pocono of the Mississippian has already been discussed in connection with the latter series, page 508. At this stage there is a known unconformity that embraces certain of the older Mississippian deposits and the Catskill Series of the Devonian, together with whatever additional time break there may be between the two periods, but it is not apparent that the upper beds of the Chemung were much abbreviated in eastern Monroe County, since the Hendricks Sandstone is present in both the Gap Mills and Caldwell Sections.

At the base of the Chemung the sedimentary record is

not so clear. Here it rests upon the Portage Series which appears to be almost wholly lacking in marine fossils as well as having no definite lithologic subdivisions for comparison with more northern outcrops. It is reasonable to believe, however, that a disconformity, embracing part of the lower beds of the Chemung and possibly part of the upper part of the Portage, exists at this stage, since the Lower (Allegrippus) Conglomerate of the Chemung was not observed and by inference the lower shales and sandstones would also be absent, although there is no definite proof.

FOSSIL LIFE, CHEMUNG SERIES.

Owing to the poor development of the Chemung in most of the local area and to the few worth while conclusions that might evidently be reached from its study, as compared to some of the other series, only a few collections were made in it. **Fossil Lot 13 on Map II** was collected by Dr. Prouty and the writer in the southern edge of Graham (now Bluefield, Virginia), as already detailed under the description of the Sunbury Shale, page 527. This collection, unfortunately, was made partly in the Sunbury Shale of the Pocono and partly in the top of the Chemung. According to Dr. Prouty it contained **Spirifer disjunctus** Sowerby, **Camarotoechia sappho** Hall, and **Lingula melie** Hall. The writer recalls that the **Lingula** was found in the black shale later identified as the Sunbury but is not so certain of the other two, **S. disjunctus** being a well-known Chemung type while **C. sappho** is found both in the Devonian and the Mississippian.

In the Blake Section, page 201, **Lots 40, 41, 42, and 43 on Map II** were collected by Dr. Prouty and the writer, as studied by the former and as detailed in the section. All of these lots appear to be in the shales and sandstones that belong between the two conglomerates of the Chemung and therefore in its middle portion.

In the Lurich Section, page 205, where the Chemung appears to be only 95 feet thick **Lots 16, 17, and 18 on Map II** were collected by Dr. Prouty and the writer, the fauna being

indicated by the former in the section, but it is not apparent what portion of the series it represented.

In the Gap Mills Section, page 230, **Lot 31 on Map IV** was collected by the writer from 200 feet of brown sandstone coming 315 feet below the base of the Hendricks Sandstone and 340 feet below the top of the series, its fauna being as detailed by Dr. Prouty in the section.

Three additional collections were made in the Hendricks Sandstone which will be discussed under the description of that member on later pages.

CORRELATION, CHEMUNG SERIES.

It is evident from the sections of Chapter V, as well as from the discussions of the present Chapter that the portion of the Chemung found in the two counties should correspond to the upper half or two-thirds of the Potomac River Chemung. It also makes the upper part of the "Giles Formation" of the Pocahontas Folio as mapped by Campbell where it is evidently combined with older Devonian beds.

DESCRIPTION OF MEMBERS, CHEMUNG SERIES.

HENDRICKS SANDSTONE.

The **Hendricks Sandstone** of Reger and Price[3] appears to form the top of the Chemung Series in northeastern Monroe County but in western Monroe and in Mercer County it was not recognized with certainty. This is generally a brown and sometimes friable deposit containing a little iron and perhaps some slight calcareous matter, some exposures being more flaggy and shaly. Its thickness varies from 10 to 50 feet and it usually carries abundant marine fossils.

In the Gap Mills Section, page 230, it is reddish-brown, flaggy, and shaly, with streaks of conglomerate and with numerous marine fossils, as exposed at the sharp turn of the road south of Red Mill and just northeast of the bridge across

[3]David B. Reger and W. Armstrong Price, Tucker County Report, W. Va. Geol. Survey, pp. 245-251; 1923.

Second Creek, Monroe County. Here **Fossil Lot 137 on Map IV** was collected by the writer, its fauna being reported by Dr. Prouty as **Camarotoechia eximia** Hall & Clarke, cf. **Grammysia subarcuata** Hall, and cf. **Cypricardinia elegans.**

Along the northwestern rim of the Pedro Syncline the Hendricks Sandstone is exposed at elevation 2850′ B. in the road across the northern end of Cove Mountain 1.3 miles southeast of Glace and only 0.2 mile southeast of the mountain summit, being reddish-brown and flaggy with an undetermined thickness. **Fossil Lot 142 on Map IV** was collected by the writer at this point, the fauna being reported by Dr. Prouty as **Aviculopecten** aff. **duplicatus** Hall, **Chonetes** sp., **Rhipidomella** sp., small crinoid stems, ostracods sp.

In the Caldwell Section, page 233, the Hendricks is noted as 50 feet thick, greenish and flaggy, as exposed along the State road (Midland Trail) 0.6 mile southeast of Caldwell. **Fossil Lot 143 on Map IV** was collected by the writer, the fauna being listed by Dr. Prouty in the Caldwell Section and the occurrence of the same species of **Rhipidomella** as found on Cove Mountain being noted. At this point the estimated interval from the base of the Hendricks down to the top of the Lackawaxen Conglomerate is 200 feet. A very good opportunity for the study of the upper Chemung beds and the Chemung-Pocono contact is afforded along this road.

UPPER (LACKAWAXEN) CONGLOMERATE.

The **Upper Conglomerate** of Stevenson[4] or the **Lackawaxen Conglomerate** of White[5] appears to be represented in northeastern Monroe County by a very prominent, pebbly stratum coming 200 to 300 feet below the top of the Chemung Series. As noted in the Caldwell Section, page 233, it is 75 feet thick and contains abundant oblong and flattened quartz pebbles, some of which are two inches or more in length.

[4]Jno. J. Stevenson, Report T2, Sec. Geol. Survey of Pa., pp. 75-81; 1882.

[5]I. C. White, Report G6, p. 96 (1882) and Report T3, pp. 88-104 (1885); Sec. Geol. Survey of Pa.

This is the general character throughout the region, the matrix being usually an olive-green color.

In Mercer County this conglomerate is apparently absent along most of the outcrops since the upper portion of the Chemung does not seem to be present, but in the Blake Section, page 201, there is one foot of conglomerate sandstone coming six feet below the top of the series that may represent it, although not so designated in the section. In the narrows of New River and in western Monroe County, also, it was not observed, the same abbreviated condition of the series being evident. In northeastern Monroe, however, it becomes a very prominent ledge, making the summit of Middle Mountain northeast of Roxalia, the crest of Cove Mountain for most of its length, the eastern end of Daniels Ridge, the southern end of Kates Mountain, and some of the unnamed ridges farther west.

So far as observed in this territory the Lackawaxen Conglomerate contains few fossils and its correlation with a similar deposit in northeastern West Virginia and Pennsylvania may be subject to question, but its relationship to the top of the series is very much the same as in the Potomac region and no other conglomerate of wide-spread occurrence is known in this part of the strata. The evidence bearing on the extent of the ledge has been lately reviewed by the writer[6], the harmony of its position with respect to the remainder of the Chemung at many different points being detailed.

ECONOMIC ASPECTS, CHEMUNG SERIES.

In the regions of its outcrop it is not apparent that the Chemung Series affords any product of much commercial value. Its soil is not only thin and poor but also fllled with stone fragments which do not readily disintegrate and which make cultivation difficult. Its shales are generally too sandy or too closely associated with sandstone to be used for brick or other clay products and its sandstones are usually too thinly

[6]David B. Reger, Mineral and Grant Report, W. Va. Geol. Survey, pp. 296-300; 1924.

PLATE XXIX.—View from Narrows, Giles County, Virginia, looking north through narrows of New River where it cuts gap through great ridge called East River Mountain on left and Peters Mountain on right. Southern slopes of these two ridges are Silurian followed by Ordovician farther north. Low wooded ridge in middle right is mostly Ordovician thrust northward over Silurian of Peters Mountain. (Photo. by Palmer & Fowler).

bedded or otherwise objectionable to be used as building stone. It contains no known minerals of value except that in regions farther northwest, where it is deeply buried under younger rocks, there are deposits of oil and gas in some of its coarser and more porous sandstones, but in the regions of its outcrop in southern Mercer and southern Monroe no hope of these products could be entertained. It is possible that there might be a little gas in some of the anticlines of Summers County and the adjoining portions of Mercer and Monroe, although the prospect of such is not encouraging.

PORTAGE SERIES.

GENERAL ACCOUNT, PORTAGE SERIES.

The Portage Series, belonging immediately under the Chemung, outcrops in southern Mercer and southern Monroe where it consists of greenish-gray shales alternating with greenish-gray flagstones, all of which are so monotonously similar and so nearly devoid of marine fossils that no distinction among them appears to be possible. This series is quite thin in Mercer but in Monroe it thickens and apparently attains proportions that compare quite well with its known occurrence in northeastern West Virginia. In the Bluefield Section, page 194, it is not differentiated from the Chemung, the thickness of the two, which also may contain a little Genesee, being 950 feet. In the Lurich Section, page 205, it is only 170 feet thick but is faulted against the Beekmantown Limestone of the Ordovician and may not all be present. In the Gap Mills Section, page 230, it is 2450 feet thick, but partly concealed, this being the maximum exposure noted, as well as being fully equal to the deposits of the Potomac region. There may be some duplication of the beds or reversals of dip in the concealed intervals of the above measurement, however, and it is therefore considered more safe to say that the thickness in the two counties varies from about 400 feet in Mercer to about 1600 feet in northeastern Monroe.

SUBDIVISIONS, PORTAGE SERIES.

In Maryland Dr. Swartz[7] has made the following subdivisions of the beds lying between the Chemung and Genesee and therefore corresponding to the Portage:

Parkhead Sandstone Member. Recurrent **Tropidoleptus cariposterus** fauna).
Shale beds.
Conglomerate sandstone beds.
Cyclonemina multistriata zone.
Camarotoechia congregata var. **parkheadensis** zone.
Liorhynchus mesacostale zone.
Woodmont Shale Member.
Beds containing Ithaca fauna (**Spirifer mucronatus** var. **posterus** fauna.)
Liorhynchus globuliforme zone.
Cladochonus-Reticularia laevis zone.
Beds containing the Naples fauna (**Buchiola speciosa** fauna).

In Mercer and Monroe Counties it is not apparent that the above subdivisions can be recognized, there being little difference in the lithologic aspects of the series from top to bottom and few marine fossils, so far as observed. Conditions for further study are not favorable, there being few localities, especially in the region of the thicker beds of northeastern Monroe, where the full series is well exposed.

TOPOGRAPHIC EXPRESSION, PORTAGE SERIES.

The Portage Series occurs in close conjunction with the Chemung and makes a similar topography although not quite so rough because it holds no large mountain-forming conglomerate like the Lackawaxen. It usually makes comparatively sharp ridges, the slopes of which are cut by many narrow gullies.

AREAL EXTENT, PORTAGE SERIES.

In Mercer County the Portage outcrop starts at the Virginia State line near the southern edge of Graham (now Blue-

[7]Chas. K. Swartz, Middle and Upper Devonian, Md. Geol. Survey, p. 411; 1913.

field, Virginia), passes eastward in the southern slope of the ridge separating the business part of Bluefield from South Bluefield and follows northeastward in the alignment of the same ridge on the south side of East River to the line of Giles County, Virginia, south of Glenlyn, crosses the narrows of New River slightly less than one mile south of Rich Creek Station and soon afterward enters Monroe County. In Monroe County it follows northeastward along the southern slope of Little Mountain to the valley of Second Creek north of Gap Mills. Its strata, from Graham to Second Creek, are all overturned and now dipping southeastward at a sharp angle. East of Second Creek it passes northeastward up Dry Run and Little Devil Creek to Roxalia, and thence down Back Creek, mainly along its southern side, to its mouth, after which it follows the valley of Cove Creek for another half mile to the line of Alleghany County, Virginia. The entire outcrop as described is approximately 60 miles long but seldom exceeds one-half mile in width.

CONTACTS, PORTAGE SERIES.

At the upper boundary of the Portage with the Chemung there is a slight change in the lithology, the Portage beds being usually greenish-gray as compared to greenish-brown in the Chemung and the flagstones of the former being usually thinner and scarcely so hard as those of the Chemung. At favorable points there is often a thinning, or depression, of the topography observable at the contact zone which serves as a clue from which more positive data may be sought. The most reliable evidence in these counties, however, is afforded by the virtual absence of marine fossils in the Portage as compared to their frequency in the overlying Chemung, but a painstaking search is often necessary to be certain of this horizon of change.

At the base of the Portage its contact with the underlying Genesee is marked by a change from the greenish-gray shales and flagstones of the former to the brown or black, fissile shales of the latter, which are entirely free from sand-

stone, and by the presence of typical Genesee fossils. It is not apparent, however, that the Genesee is always to be found beneath the Portage, there being some localities in which both the Genesee and Hamilton seem to be absent, allowing the Portage to rest upon the Marcellus.

FOSSIL LIFE, PORTAGE SERIES.

It has already been stated that the Portage of the local area appears to hold only infrequent fossils. The only point at which they were noted was at **Fossil Lot 141 on Map IV** in Monroe County in the bed of Back Creek 2 miles northeast of Roxalia. This collection, secured by the writer, is reported by Dr. Prouty as having numerous small imperfect shells of **Ambocoelia** cf. **umbonata** Conrad and **Atrypa reticularis** Linne, with the statement that they may be Portage or Chemung? The locality is near the contact zone, the lithology of the beds slightly favoring a Portage interpretation.

CORRELATION, PORTAGE SERIES.

In the almost total absence of marine fossils and in the lack of any definite lithologic differences it is not possible to determine whether the Portage of these southern counties embraces both the Parkhead and Woodmont members, including their respective substages, or whether it merely represents a portion of the Potomac phase of the series. Further painstaking research might afford some points of comparison but the probability that such would be the case is not great.

DESCRIPTION OF MEMBERS, PORTAGE SERIES.

Although divided into members in some other parts of the Appalachian region where faunal and lithologic differences of some consequence exist, such a refinement does not appear possible in the area under study, hence no further detailed description can be made.

ECONOMIC ASPECTS, PORTAGE SERIES.

The Portage Series contains no coals, iron ores, or other economic products of the baser sort and its beds are not impregnated with the precious metals. It is uniformly too sandy to be used for making brick or other ceramic products and it contains no bedded sandstones fit for building stone. Its soil is uniformly thin and poor, giving little incentive toward its cultivation. The series, in short, contains no product that appears to be of present economic interest.

GENESEE SERIES.

GENERAL ACCOUNT, GENESEE SERIES.

The Genesee Series, coming just below the Portage and being the basal group of the Upper Devonian, is a fissile or laminated shale, black on fresh fracture but weathering to a greenish-brown by loss of included carbonaceous matter. In physical appearance this shale resembles the Marcellus but its cleavage is more oblique to the bedding-planes so that sharp edges are formed. In the local area it includes no sandstone and even the shale itself at some localities was not identified. Its usual thickness is from 50 to 100 feet. Its recognition, where present, is made positive by its included marine fossils.

SUBDIVISIONS, GENESEE SERIES.

The Genesee Series has not generally been subdivided, being regarded as a lithologic individual, without physical differences from top to bottom or perceptible faunal zones.

TOPOGRAPHIC EXPRESSION, GENESEE SERIES.

In conjunction with the underlying shales of the Middle Devonian the Genesee is usually to be found only in valleys or rolling ground, being apparently incapable of making escarpments or ridges.

AREAL EXTENT, GENESEE SERIES.

In the area under study the Genesee was identified only in the valley of Potts Creek in southern Monroe County, being apparently absent from the more northern Devonian outcrops in both Monroe and Mercer, although it is possible that it may have escaped attention at a few points. In Potts Valley, as shown by Map IV, it occurs as the youngest bedded formation along the Waiteville Syncline, starting 2½ miles northeast of Waiteville and extending northeastward down the creek by way of Laurel Branch to the line of Craig County, Virginia, the entire length of the outcrop in Monroe being about six miles and its width about one-half mile.

CONTACTS, GENESEE SERIES.

The upper contact of the Genesee with the Portage has been discussed in connection with the latter series on a previous page. At its base it rests upon the Hamilton Series, the intermediate Tully Limestone of New York being absent in southern West Virginia as well as farther northeast in the Potomac counties. The Landes Limestone of Grant County, which on the South Branch of the Potomac divides the Hamilton from the Genesee and which at some localities contains Hamilton fossils and at others holds Genesee types and is therefore of a transitional nature, is also absent. Between the Hamilton and Genesee a very considerable difference in fauna appears to exist and there is also a physical change, the Hamilton being uniformly greenish-brown and sandy while the Genesee is more generally black.

FOSSIL LIFE, GENESEE SERIES.

In the Genesee, which in southern Monroe County contains a somewhat sparing marine fauna, only two collections were made, these being taken to prove the age of the formation. **Fossil Lot 64 on Map IV** was collected by Dr. Prouty and the writer in the road on the north side of Potts Creek 1.9 mile southwest of Laurel Branch. According to Dr. Prouty

this lot contains **Styliolina fissurella** Hall, **Buchiola** cf. **conversa** Clarke, and **Lingula** sp. **Fossil Lot 65 on Map IV** was collected by Dr. Prouty and the writer at elevation 2145′ B. at the northern edge of Potts Valley in the road ascending Peters Mountain 0.2 mile north of Laurel Branch. According to Dr. Prouty's report this lot contains **Styliolina fissurella** Hall, **Buchiola** cf. **conversa** Clarke, and **Buchiola retrostriata** (Von Buch). Both of the above collections appear to be in the lower portion of the Genesee quite near its contact with the Hamilton Series. All of the species named are quite common in the Genesee and appear to make its correlation certain at this isolated outcrop.

CORRELATION, GENESEE SERIES.

As stated above the fossils found in Potts Valley comprise an assemblage which makes reasonably certain the presence of the Genesee along the Waiteville Syncline of southern Monroe County. It is possible, also, that some remnants of the Genesee may exist in the longer Devonian outcrop which passes across both Mercer and Monroe Counties entirely north of East River Mountain and Peters Mountain, although nothing of the kind was observed in the territory. In northeastern West Virginia the Genesee has been identified in the Potomac region where it exists in considerable quantity and where its fauna and lithology compare closely with these features at its type locality in New York. It has also been described in southwestern Virginia and in other southern Appalachian States so that there appears to be little doubt that it has an extent of many hundreds of miles throughout this region. Its very uniform character and quite persistent fauna would indicate a quiet sea of considerable depth in which this thin deposit of silt could accumulate without external disturbance.

DESCRIPTION OF MEMBERS, GENESEE SERIES.

As previously stated, the Genesee has no pronounced lithologic differences from top to bottom and apparently no distinctive faunal zones by which it may be subdivided. That

being the case the general account of the series affords the necessary description of its parts.

ECONOMIC ASPECTS, GENESEE SERIES.

The Genesee makes a yellow soil which is thin and usually barren, there being frequent exposures where vegetation barely covers the extruding shales. It contains no mineral products of value except that it holds some slight deposits of natural gas in southwestern West Virginia, but there could be no hope of such occurrences in the surface outcrops of Monroe County and probably none in Summers County and the northern ends of Mercer and Monroe where the Genesee may exist beneath the surface.

MIDDLE DEVONIAN ROCKS.

HAMILTON SERIES.

GENERAL ACCOUNT, HAMILTON SERIES.

The Hamilton Series, comprising the upper division of the Middle Devonian beds of southern West Virginia and coming just below the Genesee of the Upper Devonian, is a deposit of green, argillaceous or sandy shales, varying from an apparent minimum of nothing up to an approximate maximum of 500 feet, although a total of 635 feet was measured in the Gap Mills Section, page 231, but this may partly represent the Genesee since it was imperfectly exposed. At some localities marine fossils occur in some abundance while at others they are not so apparent. The series as a whole fails to show the diagonal cleavage, chunky weathering, and occasional concretions or thin beds of lime that make its appearance distinctive in northeastern West Virginia, some of these features, also, being reported as more common in States farther northeast. It also fails to exhibit the profusion of marine invertebrates that make it such an interesting collection ground in regions nearer to its type locality.

SUBDIVISIONS, HAMILTON SERIES.

In the early description of the Hamilton by James Hall at its type locality in New York no subdivisions were made, but in 1885 Dr. I. C. White divided it into five members in northeastern Pennsylvania, and in 1899 Dr. A. W. Grabau recognized three groups in the region of Lake Erie in western New York. Later, in 1907, the New York State Survey, under the auspices of Dr. John M. Clarke, adopted a three-part subdivision differing slightly from that of Grabau. In 1924 the writer recognized a limestone, occurring at its upper boundary in Grant County, West Virginia, that had apparently escaped previous attention. These various groupings have been reviewed on pages 312-314 of the Mineral and Grant County Report of the Survey, but are not herein repeated because there is no good reason for belief that the Hamilton of Mercer and Monroe contains the necessary faunal and lithologic differences by which its conformity to any of these groupings could be shown.

TOPOGRAPHIC EXPRESSION, HAMILTON SERIES.

Having neither resistive sandstones nor massive ledges of any description the local phase of the Hamilton does not form bold mountains and escarpments. An extensive outcrop of such shales as it contains would form valleys or gently rolling topography but there is little opportunity for the development of such an expression, since its narrow outcrop along the northern slope of Gap Mountain consists of nearly vertical beds protected by a buttress of Oriskany Sandstone only a few hundred feet southward in the same mountain, but in Potts Valley its more typical weathering is shown along either limb of the Waiteville Syncline in conjunction with the Genesee and Marcellus, where the surface formed by these three series is comparatively gentle except for many boulders which have rolled down from the outcrops of other rocks.

AREAL EXTENT, HAMILTON SERIES.

In Mercer County and in southwestern Monroe no trace of the Hamilton Series was observed along the narrow belt in which it should occur so that in this region it would seem that no deposition of these shales occurred, their disappearance being in harmony with the southwestward thinning of nearly all the Devonian. In eastern Monroe it first appears on the waters of Dropping Lick Creek about one mile southwest of Zenith and then follows northeastward, crossing Turkey Creek slightly east of McGlone and turning more toward the north until it reaches the western end of Gap Mountain, and thereafter resuming the general regional strike and forming part of the northern slope of Gap Mountain until it reaches the line of Alleghany County, Virginia, just south of Cove Creek, the total length of the outcrop as described being about 19 miles and its width generally less than one-fourth mile. Probably the best opportunity for its study along this strip is afforded in the valley of Second Creek about one-half mile north of Gap Mills but this exposure is far from perfect.

In Potts Valley it makes a considerable outcrop, as shown by Map IV, there being an area along the North Fork Syncline and the southern slope of Peters Mountain in the drainage of North Fork of Potts Creek and another along the Waiteville Syncline around Waiteville on South Fork of Potts Creek. Passing eastward and dipping at the same time these outcrops converge where the North Fork Syncline combines with the Waiteville Syncline 1½ miles northeast of Waiteville and thereafter for about one mile comprise the surface rocks along the latter basin. About 2½ miles northeast of and below Waiteville the descending basin holds a cover of Genesee and the Hamilton divides, one limb of which skirts the southern base of Peters Mountain while the other occupies sloping ground south of Potts Creek until both enter Craig County, Virginia, between Laurel Branch and Linton, being of unequal length on account of the irregular State boundary. In this region there are some good local exposures of portions

of the series, particularly around Waiteville and Laurel Branch, where fossils may be collected in some abundance, but on account of the frequent reversals of dip and possible duplications no reliable measurements of thickness appears to be possible.

CONTACTS, HAMILTON SERIES.

The upper contact of the Hamilton with the overlying Genesee has already been discussed under the description of the latter series on previous pages. Its base invariably rests upon the black shales of the Marcellus, there being some probability of a slight disconformity at this zone caused by thinning in both the Hamilton and the Marcellus in addition to the comparatively insignificant time break that is always in evidence at this stage when carefully studied.

FOSSIL LIFE, HAMILTON SERIES.

Along the northern slope of Gap Mountain and in the region to the westward the outcrops of the Hamilton were not intensively studied but at most points they do not appear to be prolific in marine life. In Potts Valley, however, there is rather abundant fauna in the neighborhood of Waiteville and Laurel Branch, as indicated at the following locality:

Local Measurement at Fossil Lot 66.

Sweet Springs District, Monroe County; on south slope of Peters Mountain in highway between Gap Mills and Laurel Branch and 0.4 mile northeast of latter point; dip, southeastward 40°; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Hamilton Series (125′)		
1. Shale, black, fissile	75	75
2. Shale, greenish-gray, with marine fossils (2270′ B.). Lot 66; contains **Buchiola halli** Clarke, **Styliolina fissurella** Hall, **Tentaculites bellulus** Hall, **Productella** sp., **Phacops rana** Green, **Amplexus hamiltoniae** Hall, **Chonetes** sp., **Platyostoma** sp., crinoid stem	50	125
Marcellus Series (25′)		
3. Shale, black, fissile, with limestone concretions and marine fossils; contains **Liorhynchus limitare**, etc.; visible	25	150

At the above exposure **Fossil Lot 67 on Map IV** was collected by Dr. Prouty and the writer, the fauna having been identified by the former. The contact with the Marcellus at this point is quite distinct but the full thickness of the Hamilton is not represented.

CORRELATION, HAMILTON SERIES.

The correlation of the Hamilton of Monroe County with that of the beds so described from New York to West Virginia is evident, both from the fauna and from the lithology and stratigraphic associations, and since these deposits have always been readily followed their occurrence and description involve no controversial features. In Monroe County it is not apparent that all the northeastern stages could be recognized, even with intensive study, and furthermore there is no available evidence for comparison with the Giles Formation of Campbell which in the southern part of the Pocahontas Folio might be supposed to include some Hamilton along with its other components.

DESCRIPTION OF MEMBERS, HAMILTON SERIES.

Comment has already been made on the difficulty of attempting to separate the local Hamilton into members as has been done in more northeastern States. It presents few lithologic differences from top to bottom and the fauna has not been sufficiently studied to determine whether it has enough variety to make subdivisions possible. In the present state of knowledge on this subject the description of the whole series must be offered in place of more detailed data.

ECONOMIC ASPECTS, HAMILTON SERIES.

The Hamilton Series makes a rather thin and sandy soil, which responds to artificial fertilization and which is readily tillable because of its disintegration into small particles, but in Monroe County nearly all the outcrops are so covered by large boulders from higher topographic levels that their value

for agriculture is usually little. Aside from some slight value as material for surfacing local stretches of rough or muddy road its shales are not of any present economic importance, since they do not contain minerals of any kind in commercial amounts and are too sandy to be used for brick or other ceramic products.

MARCELLUS SERIES.

GENERAL ACCOUNT, MARCELLUS SERIES.

The Marcellus Series, coming just below the Hamilton and locally overlying the Oriskany, is a deposit of black, bituminous and fissile shale, varying in thickness from 100 to 300 feet and sometimes containing a little black, lenticular limestone. The formation is of constant occurrence, being readily visible at nearly all points where its horizon is exposed, and being recognizable by its lithology and stratigraphic associations. It normally contains a scanty but definite marine fauna but at many localities it has been so altered by lateral pressure that it has almost the appearance of a schist and all traces of organic remains have been obliterated.

In the Bluefield Section of Mercer County, page 194, the Marcellus is only 25 to 50 feet thick, being crushed and faulted against the Ordovician, or Cambrian? dolomites. In the Pigeon Creek Section, page 202, it is 90 feet thick and is slickensided and metamorphosed until no fossils are recognizable where it abuts against the Ordovician. In the narrows of New River in the edge of Giles County, Virginia, it is totally faulted out on the west side but it is visible on the east side where it is much crushed against the Beekmantown Limestone of the Ordovician, its thickness being an uncertain quantity. In the Gap Mills Section of Monroe County, page 230, it is apparently covered or locally absent by disconformity, although it is visible farther east and west along the same outcrop. In Potts Valley it covers a considerable territory and apparently is about 300 feet thick at some points, although it is usually so much disturbed by reversals of dip and possible

duplications that accurate measurement of its thickness is hardly possible.

SUBDIVISIONS, MARCELLUS SERIES.

In the Mineral and Grant Report of the Survey, pages 318-327, the subdivisions of the Marcellus Series in the Potomac region of West Virginia in their relationship to those of other northeastern States have been lately reviewed by the writer. The descending succession in that region, which appears to be the same as in Monroe County, is as follows, with the thickness figures revised to suit the latter area:

Marcellus Series:	Feet.
Black shale with typical Marcellus fauna and lithology	50 to 200
Limestone, Lower Selinsgrove, black, carbonaceous and often shaly, probably carrying a mixed Marcellus and Onondaga fauna	0 to 25
Shale, Selinsgrove, usually black and fissile, but occasionally gray and calcareous; mixed Marcellus and Onondaga fauna	10 to 75

The subdivisions as found in Mineral and Grant Counties are herein applied to Mercer and Monroe Counties on the evidence of the lithology which is quite in accord. The faunal evidence in the latter counties is incomplete, however, partly on account of the frequently metamorphosed condition of the beds and partly because one important collection was lost in transit. The incomplete data, as far as they go, are confirmatory of the faunal statements relative to the upper two subdivisions and it is hardly to be supposed that Onondaga forms could be found in the Lower Selinsgrove Limestone without the presumption of their presence in the Selinsgrove Shale.

TOPOGRAPHIC EXPRESSION, MARCELLUS SERIES.

The Marcellus Series of the two counties makes no ridges when free from external influences, since it weathers into valleys or rolling lowlands, but at various localities where the beds dip steeply it is preserved on high ground through the

protective association of the Oriskany Sandstone which adjoins it.

AREAL EXTENT, MARCELLUS SERIES.

In Mercer County, as shown by Map II, the outcrop of the Marcellus is confined to a narrow strip starting at the line of Tazewell County, Virginia, near the Bluefield Fair-Grounds and passing northeastward through the northern part of South Bluefield and thence continuing in the same direction through the low ridges on the south side of East River to the line of Giles County, Virginia, about one mile south of Glenlyn. The total length is approximately 22 miles but its width is seldom more than 200 to 300 feet since the strata are overturned and now dipping only slightly southward, being faulted against the Ordovician dolomites through nearly all the distance. The position with respect to East River varies from less than one-fourth mile to more than one mile, this being caused by the meanderings of the river rather than by any important changes in the line of the strike.

In the northern end of Giles County this same narrow outcrop continues northeastward crossing New River in the narrows about one mile south of Rich Creek Station and entering Monroe County near the head of Scott Branch 1½ miles southeast of Peterstown. On the west side of New River, however, the Marcellus appears to be totally faulted out but on the east side it is visible, although much distorted and metamorphosed.

In Monroe County this same outcrop continues for 11 miles northeastward, as shown by Map IV, being in the lowlands between Little Mountain and Peters Mountain and being the first formation north of the St. Clair Fault through all this distance except in a brief sector on Rich Greek southeast of Brick Church where the Oriskany intervenes next to the fault. Near the western branch of Rock Camp Creek about two miles from Rock Camp village, the Marcellus is completely faulted out and so remains for three miles or more northeastward along the fault, but on the drainage of Drop-

ping Lick Creek about three-fourths mile northwest of Wallace School it reappears and thence extends northeastward, but is thereafter separated from the St. Clair Fault by one or more older formations, although it still stands at a nearly vertical angle and its outcrop is little wider than in Mercer County. It passes just south of Zenith, about one-third mile southeast of McGlone, and about one-third mile north of Gap Mills, and then follows for several miles along the northern slope of Gap Mountain, but crosses to the south side of this ridge two miles west of Sweet Springs and finally enters Alleghany County, Virginia, about 1¼ miles northwest of Sweet Springs and one-half mile southeast of Cove Creek.

In Potts Valley of Monroe County, as shown by Map IV, the Marcellus outcrops extensively. One of these outcrops starts on the southern slope of Peters Mountain at the line between Monroe County and Craig County, Virginia, about one mile west of Linton and continues southwestward along the slope of the mountain for eight miles, but in the region northwest of Waiteville it turns southward and passes across the valley of North Fork of Potts Creek and into the valley of South Fork of Potts Creek about one mile west of Waiteville, and thence again continues southwestward along the Waiteville Syncline and up the valley of South Fork nearly four miles to the line between Monroe County and Giles County, Virginia, which latter it enters just east of Kire Station.

On the South Fork of Potts Creek another outcrop turns eastward in the region just west of Waiteville, and passing just south of that village extends northeastward for 6½ miles to the Monroe-Craig County line, being on the south side of the Waiteville Syncline and from one-half to one mile south of Potts Creek, with a width that is sometimes more than one-half mile.

In the extreme southern end of Monroe, next to Giles County, the Marcellus is retained for about one mile along the Ray Syncline, and in the same basin farther northeast it is present for 3½ miles, starting at Crosier Branch of Potts Creek and including the cuts of the Norfolk and Western Rail-

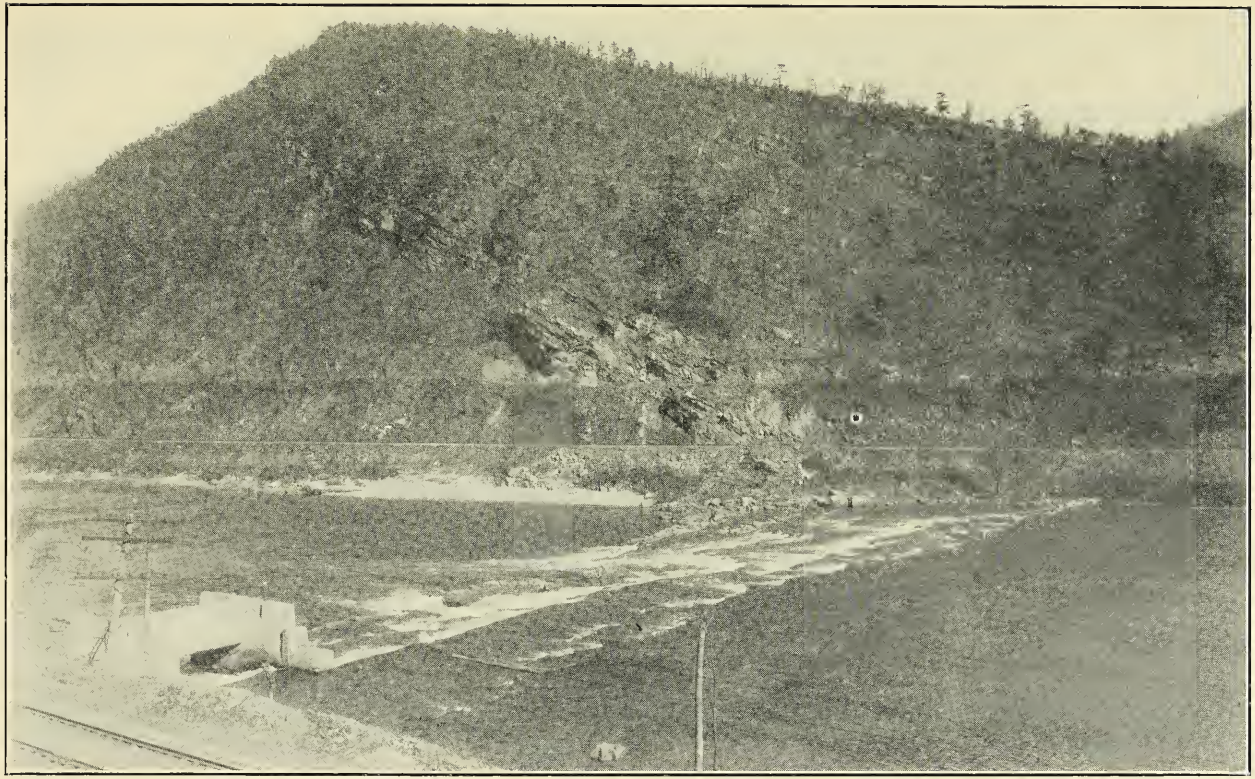


PLATE XXX.—Extreme west end of Peters Mountain looking eastward across New River, Giles County, Virginia, one mile north of Narrows. Middle cliff and river reef made by White Medina Sandstone (left) and Iron Sandstone (right) separated by a few feet of shale. Shales and weak ledges of Red Medina at left. Two quartzites in Clinton visible near top of right-hand slope. Bedding natural and dip southeast 30°. See Rich Creek Section. (Photo. by Palmer & Fowler).

way near Ray Station and continuing into the narrow upland valley of Wilson Branch, but stopping about one mile west of the Craig County line which in that region makes a north and south offset.

The outcrops in Potts Valley afford much better opportunities for study than those north of the St. Clair Fault, the beds being only slightly metamorphosed so that the fossils are very well preserved and the lithology has been but little changed.

CONTACTS, MARCELLUS SERIES.

The upper contact of the Marcellus with the overlying Hamilton has been discussed in the description of the latter series on previous pages. Its base rests unconformably upon the Oriskany, there being little evidence that much of the Onondaga is present since its typical flintstones and corals are not found, and its fossils which are locally found in beds that have typical Marcellus lithology may be more recurrent than anything else. The Schoharie and Esopus Grits, which occur between the Onondaga and Oriskany beds in New York State, are entirely absent, enlarging the hiatus that exists between the Marcellus and Oriskany.

FOSSIL LIFE, MARCELLUS SERIES.

In the highly compressed and partly metamorphosed outcrops of the Marcellus north of the St. Clair Fault in Mercer County there are only occasional points where fossils may be observed and in these cases they are usually poorly preserved. Some miles southward in Bland County, Virginia, **Fossil Lot 3** was collected by Dr. Prouty and the writer on a branch of Laurel Creek at the foot of East River Mountain about two miles southwest of Rocky Gap. According to Dr. Prouty this exposure contained **Schizobolus** sp. close to **S. concentrica** (aa), and **Schizobolus** sp. (a), the inference being that both species are abundant.

Along the Marcellus outcrop north of the St. Clair Fault

in southwestern Monroe County conditions are much the same as in Mercer, the shales being crushed and slickensided, but in the region east of Gap Mills there was less compression and a few fossils are preserved as is evident from the following local measurement:

Local Measurement at Fossil Lot 57.

Sweet Springs District, Monroe County; on a branch of Cove Creek, starting in the highway 1.4 miles northwest of Sweet Springs and ascending the hill southeastward to the St. Clair Fault-line; strata overturned and now dipping southeastward; thicknesses estimated; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Marcellus Series (85′)		
1. Shale, black, fissile, visible	50	50
2. Limestone, Lower Selinsgrove, dark, shaly, with a few marine fossils. Lot 57 (collection lost)	25	75
3. Shale, Selinsgrove, black	10	85
Oriskany Sandstone (100′)		
4 Sandstone, Oriskany, brown, coarse, broken, to St. Clair Fault (2020′ B.); contains brachiopods (Spirifer)	100	185
Beekmantown Limestone ? (....)		
5. Dolomite, dove-colored, with porous chert, on south side of fault	..	...

Fossil Lot 57 on Map IV was collected from the Lower Selinsgrove Limestone by Dr. Prouty and the writer, but this collection unfortunately was lost in transit and not even a field notation on the species is available.

In Potts Valley there are many points where fossils may be collected in the Marcellus. On page 555 the Local Measurement at **Fossil Lot 66 on Map IV,** which was made in the lower portion of the Hamilton Series, also records the presence of **Liorhynchus limitare** in beds below the Hamilton, this being the guide fossil of the Marcellus Series. **Fossil Lot 135 on Map IV** was collected by the writer in the cut of the Norfolk and Western Railway on the north side of South Fork of Potts Creek 1.1 miles west of Waiteville mainly in the Lower Selinsgrove Limestone which is there dark, shaly, 10 feet thick, and bedded in black shale. Dr. Prouty reports the presence of **Styliolina fissurella** Hall (aa), **Tentaculites gracilistriatus** Hall (aa), **Liorhynchus limitare** Vanuxem,

Buchiola halli Clarke (a), and **Ambocoelia umbonata** Conrad. The mixed Genesee, Marcellus, and Onondaga species at this locality are evident but Dr. Prouty calls it Marcellus which is in agreement with the stratigraphy.

The scanty collections obtained are far from satisfactory but still are sufficient to define the age of these deposits in the two counties.

CORRELATION, MARCELLUS SERIES.

Considering the few collections of marine fossils available and the generally poor outcrops it is hardly pertinent to review the finer points of the correlation of these black beds coming above the Oriskany but in the Mineral and Grant County Report of the Survey, where much better exhibits were available, the writer has indicated his views on the relationship of the West Virginia phase of this series to its more typical development in the northeastern States, and under the subject of "Subdivisions" in the present Report it has been indicated that apparently the same portions of the series are found in southern West Virginia as occur in the Potomac region. In Mineral and Grant Counties **Liorhynchus limitare** was found both in the black shales above the Lower Selinsgrove Limestone and in the black shales below it, this being the guide fossil of the Marcellus, but at the same time other species were found in the limestone and the lower shale which are more or less common in the Onondaga. Apparently much the same condition occurs in Mercer and Monroe Counties so that it does not appear advisable to consider any of these beds as truly representative of the Onondaga, especially since its flintstones and corals are not found. These beds are therefore correlated with the Marcellus Series in the belief that the true Onondaga has largely, if not entirely, disappeared.

DESCRIPTION OF MEMBERS, MARCELLUS SERIES.

MARCELLUS SHALE.

The black, fissile shale of typical Marcellus aspect which

occurs at the top of the series and which is recognized by most authors as most certainly representative of the New York Marcellus, is present in the two counties but may be recognized with more certainty in Monroe, since there appears to be no Lower Selinsgrove Limestone in Mercer by which the lower portion of the series may be distinguished from the upper shale. This upper shale apears to vary from 50 to 200 feet in thickness and holds a scanty marine fauna in which **Liorhynchus limitare** was observed at a few localities. At **Fossil Lot 57 on Map IV**, on a branch of Cove Creek 1.4 miles northwest of Sweet Springs, there is a visible thickness of 50 feet above the Lower Selinsgrove Limestone, as published in a local measurement on page 562. In Potts Valley it is exposed on the mountain road north of Laurel Branch just beneath the Hamilton Series, there being **Liorhynchus limitare** in the 25-foot bed that is visible, as noted in **Fossil Lot 66 on Map IV**, page 555. At other points in Potts Valley there is a large amount of black shale which at some localities contains **Liorhynchus limitare** and the total thickness appears to approach 200 or 300 feet in places but the limestone is often absent so that the upper shale may not readily be distinguished from the lower.

LOWER SELINSGROVE LIMESTONE.

The **Lower Selinsgrove Limestone** of White[8] belonging near the base of the Marcellus Series and separating the upper shale from the lower or Selinsgrove Shale, is present at a few localities in southeastern Monroe County, being dark and shaly, with an apparent maximum thickness of about 25 feet, and carrying a mixed Marcellus and Onondaga fauna. At **Fossil Lot 57 on Map IV**, on a branch of Cove Creek 1.4 miles northwest of Sweet Springs, it is 25 feet thick, dark, and shaly, with marine fossils, as noted in the local measurement at this place, page 562. Unfortunately the collection at this point was lost, as previously explained. In Potts Valley it is visible in the cut of the Norfolk and Western Railway on the north

[8] I. C. White, Report G7, Sec. Geol. Survey of Pa., pp. 79-80; 1883.

side of South Fork of Potts Creek, 1.1 miles west of Waiteville, being dark, shaly, and 10 feet thick and bedded in black shale, with a southward dip of 48 degrees. **Fossil Lot 135 on Map IV** was collected at this exposure, as already detailed on page 562. On Trout Branch of Potts Creek 0.8 mile southeast of Laurel Branch it appears to be represented by 10 feet of dark-gray, calcareous shale, the dip being northward at the rate of 27 degrees and the elevation 2150′ B. In the edge of Craig County, Virginia, in the same valley, the following observation was obtained by Dr. Prouty and the writer along Ewin Run of Potts Creek 0.8 mile south of Linton, the measurement being made from north to south across the line of a local fault:

		Feet.
1.	Shale, black, highly compressed, with inclusions of black marble, remnants of **Lower Selinsgrove Limestone** (dip, southeast, 45°)	10
2.	Concealed, fault-plane	50
3.	Limestone, highly crystalline and effervescent; contains bryozoa, **Stones River?**, visible	25

The bryozoa noted in the lower limestone were somewhat doubtfully attributed to the Stones River by Dr. Prouty and if that is the proper interpretation there is a fault of considerable throw between the Lower Selinsgrove and the Stones River. It is barely possible that the lower limestone may be the Helderberg with only a disconformity existing between the two.

SELINSGROVE SHALE.

The **Selinsgrove Shale** of White[9], which apparently occupies that portion of the Marcellus Series below the Lower Selinsgrove Limestone, is represented in Monroe County and possibly also in Mercer, although its presence in the latter county is hardly capable of proof. This is a black fissile shale, with a maximum thickness of 50 to 75 feet and with a fauna which is apparently of mixed Marcellus and Onondaga aspects. It

[9]Ibid., pp. 80-81.

is visible at **Fossil Lot 57 on Map IV** on Cove Creek northwest of Sweet Springs and in Potts Valley may be identified at several points, due to the presence of the Lower Selinsgrove Limestone above it.

ECONOMIC ASPECTS, MARCELLUS SERIES.

The Marcellus Series weathers to a very thin, yellow soil at most localities, the only exceptions being the local enrichment that may be caused by the presence of the Lower Selinsgrove Limestone. In considerable areas the black shales extrude from the ground in an almost unweathered state so that little soil of any kind is formed. The Lower Selinsgrove Limestone is generally too impure for commercial purposes in competition with the abundant and very pure beds of other age that may usually be found not far from its outcrop. In Kentucky, Ohio, and some other States the black shales of the Marcellus contain bituminous matter from which petroleum may be distilled but in Mercer and Monroe they have been so baked and compressed by lateral folding that it is doubtful whether any appreciable amount of oily matter remains in them.

LOWER DEVONIAN ROCKS.

ORISKANY SANDSTONE.

GENERAL ACCOUNT, ORISKANY SANDSTONE.

The Oriskany Sandstone which forms the upper subdivision of the Lower Devonian Rocks of Mercer and Monroe Counties, and which next underlies the Marcellus Series of the Middle Devonian, is represented in these counties by a gray or brown, massive, coarse, and sometimes ferruginous sandstone, containing a sparse marine fauna, and having frequent pockets of iron ore with traces of manganese. Its thickness varies from 50 to 150 feet, and in the regions of the two counties where its horizon outcrops it is nearly always present but is often difficult of recognition because it has been

so much metamorphosed that its fossils are almost entirely obliterated making it greatly resemble the white quartzites of the Clinton and Medina Series.

In the Bluefield Fair-Grounds Section, page 195, the Oriskany is very well displayed, being 130 feet thick and containing marine fossils. In Monroe County it is exhibited in the Gap Mills Section, page 231, having a thickness of 140 feet and containing a little chert which may partly belong to the Helderberg Limestone since the exposure is imperfect and the contacts are not plain.

SUBDIVISIONS, ORISKANY SANDSTONE.

The Maryland Geological Survey (Lower Devonian, pages 91-92) has subdivided the Oriskany of that State into two members, the **Ridgeley Sandstone** at the top, comprising two-thirds or three-fourths of the formation, and the **Shriver Chert** at the base, including the remainder. These subdivisions are easily recognizable in the Potomac region of West Virginia where both of them contain many marine fossils of typical Oriskany aspects. In southern West Virginia, however, the Shriver Chert has almost, if not entirely, disappeared, leaving only the Ridgeley Sandstone as the representative of the formation.

TOPOGRAPHIC EXPRESSION, ORISKANY SANDSTONE.

With few exceptions the Oriskany outcrops of the two counties occur in regions where the strata have been greatly disturbed, being tilted at high angles or even overturned, and this circumstance, combined with the naturally massive and arenaceous character of the rock, makes a bold topography at nearly all points, although few of the large mountains may be attributed to this formation, since most of its outcrops are in the nature of shoulders occurring along the lower slopes of the ridges, the backbones of which are usually made by the harder rocks of the Medina and Clinton Series. These Oriskany shoulders may be observed at some points along the northern side of Gap Mountain, along the southern slope of

Peters Mountain, along the Norfolk and Western Railway in Potts Valley southwest of Waiteville, and along some of the other ridges of southern Monroe County.

AREAL EXTENT, ORISKANY SANDSTONE.

In Mercer County, as shown by Map II, the Oriskany Sandstone outcrops only in a brief strip about one mile in length, occupying some low ridges which extend from South Bluefield westward to the line of Tazewell County, Virginia, at the Bluefield Fair-Grounds. East of this locality it is entirely covered by the Ordovician overthrust along the St. Clair Fault and this condition continues across the northern end of Giles County, Virginia, in the narrows of New River, and through southwestern Monroe County to the headwaters of Rich Creek southeast of Brick Church where there is a brief exposure of hardly more than one-half mile just north of the St. Clair Fault. On the waters of Dropping Lick Creek about one mile southwest of Zenith the Oriskany reappears north of the fault, from which it soon becomes separated by older formations, and extends northeastward passing just northwest of Crimson Springs, crossing Turkey Creek about one-half mile east of McGlone, and then circling northward to the northern slope of Gap Mountain which it follows for 10 to 12 miles, but in the region west of Sweet Springs it crosses to the southern side of Gap Mountain and so remains to the line of Alleghany County, Virginia, about one-half mile south of Cove Creek. In all these intermittent outcrops along the northern side of the St. Clair Fault the Oriskany stands at a nearly vertical angle, being often overturned and the width of the exposure being little more than the thickness of the member.

In Potts Valley an outcrop of the Oriskany starts at the Monroe-Craig County line on the southern slope of Peters Mountain about one mile west of Linton, and extends southwestward nearly to the head of North Fork of Potts Creek, as shown by Map IV, and there turns southward across the North Fork Syncline and the eastern end of Fork Mountain,

at the southern base of which it again turns westward and passes along the southern slope of Fork Mountain until it reaches the line of Giles County, Virginia, slightly east of Kire Station.

Just to the southward another Oriskany outcrop enters Monroe County from Giles County on the south side of South Fork of Potts Creek, just east of Kire Station, and passes eastward along the northern slope of Little Mountain, crossing Ray Fork just north of Ray Station, beyond which it soon divides into two limbs, the more northern of which follows along the northern slope of Little Mountain and enters Craig County, Virginia, about two miles southeast of Laurel Branch and the more southern of which passes eastward along the southern slope of Little Mountain and into Craig County, three miles northeast of Ray Station. In this latter locality, however, the outcrop extends southward across the Ray Syncline and then turns southwestward along the southern limb of this basin to Crosier Branch and then for a time occupies the whole basin, but before passing into Giles County, about one-half mile north of the extreme southern end of Monroe, it is again divided into two limbs by a brief outcrop of Marcellus.

CONTACTS, ORISKANY SANDSTONE.

The upper contact of the Oriskany with the overlying Marcellus has already been discussed on previous pages under the description of the latter series. Its base in the local area rests upon a remnant of the Helderberg Limestone at some localities, while at others it appears to come directly over the Clinton Series of the Silurian. When the Helderberg is present it is not apparent that much unconformity exists, although the Becraft member of the Helderberg appears to be entirely absent, allowing the Oriskany to rest directly upon the New Scotland member. At this boundary the very distinct change in lithology does not appear to be reflected in the faunal contents of the two formations, since there is always an intergradation of species between the two. In localities where the Helderberg is totally absent, however, a vast unconformity

is at once apparent, measured not only by the time break of indefinite amount that always exists at the boundary of the Silurian and Devonian Periods, but also by the much more definite absence of the Coeymans and Keyser members of the Helderberg of the Devonian, and by a large part of the upper Silurian including the Bossardville and Rondout Limestones, and the Bloomsburg Series, which together make the Salina Formation, and including the Niagara Limestone. When compared with the Potomac region of northeastern West Virginia it is evident that probably 1200 to 1500 feet of principally calcareous beds are absent in southern West Virginia, so that owing to the very long time required for the accumulation of such sediments an unconformity of major rank is at once apparent.

FOSSIL LIFE, ORISKANY SANDSTONE.

The Oriskany of these counties has been so much compressed and metamorphosed that few marine fossils may now be distinguished in it. Here and there may be found a fragment of its guide fossil, **Spirifer arenosus,** or of **Hipparionyx.** At the southeastern gate of the Bluefield Fair-Grounds **Fossil Lot 38 on Map II** was collected by Dr. Prouty in the loose material of a sand quarry, as indicated in the Bluefield Fair-Grounds Section, page 195, but when the collection was studied the specimens were found to be mixed with Helderberg species which had evidently rolled down from the hill above, so that Dr. Prouty considered it inadvisable to publish this list. In Monroe County there are some crinoids and brachiopods visible at the exposure in the gap of Second Creek north of Gap Mills, and the ledge contains Spirifer near **Fossil Lot 57** on Cove Creek; and in Potts Valley a few fragments of brachiopods were found in one of the iron ore prospects in Craig County, Virginia, slightly east of Paint Bank. At a few other localities some imperfectly preserved forms were noted but they were generally so poor that no further collections were made.

The almost barren nature of the Oriskany in these coun-

ties, as compared to its abundant fossil life in northern West Virginia and other Appalachian States farther north, often makes it quite difficult to distinguish this formation from the gray sandstones of the upper portion of the Clinton Series which it generally closely adjoins, and the further circumstance that iron ore and manganese are found in both the Oriskany and Clinton adds to the confusion that occurs in the rock study, especially since the thin Helderberg Limestone is often completely absent or quite covered by debris.

CORRELATION, ORISKANY SANDSTONE.

It has already been stated that the portion of the Oriskany found in Mercer and Monroe appears to belong principally to the Ridgeley Sandstone member of the Potomac region of West Virginia and Maryland. The relationship of this ledge to the type locality in New York and to other neighboring States has been discussed at length by the Maryland Survey and by other organizations. It is true that at some points in Monroe County the Oriskany is somewhat cherty, suggesting the Shriver Chert phase of the Potomac region but these indications are so few and so uncertain that little significance may be attached to them.

DESCRIPTION OF MEMBERS, ORISKANY SANDSTONE.

The fact that the Oriskany Sandstone of the two counties is mainly made up of the Ridgeley Sandstone indicates that the general description of the formation in previous pages embraces the description of this member. In Chapter XV, however, under the subject of "Iron Ore" will be found further detailed sections of the formation.

ECONOMIC ASPECTS, ORISKANY SANDSTONE.

In Mercer County the brief exposure of the Oriskany in the ridge west of South Bluefield has been utilized for building sand, as will be later mentioned in Chapter XVI under the subject of "Road Material". In Monroe County this sand-

stone often carries considerable deposits of iron ore, some of which are mixed with small quantities of manganese. These exposures and prospects will be described at some length in Chapter XV under the subject of "Iron Ore".

It would be quite possible to use the Oriskany Sandstone for masonry, since it is often very hard and quartzitic at many of its exposures in Monroe County, but these are generally so isolated that its exploitation would hardly be practicable. It is not apparent, however, that any of its exposures are sufficiently pure to be used for glass-sand as is done in Morgan County.

HELDERBERG LIMESTONE.

GENERAL ACCOUNT, HELDERBERG LIMESTONE.

The Helderberg Limestone, belonging just under the Oriskany Sandstone and being the basal formation of the Devonian in the Appalachian region, is present at a few localities in Mercer and Monroe Counties, but as a rule is quite insignificant, being usually less than 50 feet thick and often entirely absent. When present it contains marine fossils of New Scotland age which identify it with the lower portion of the Devonian. It is usually cherty, impure, and quite unfit for economic use. In the Bluefield Fair-Grounds Section, page 195, the Helderberg is poorly exposed but appears to be about 235 feet thick and contains marine fossils, but no such thickness was observed at any other locality in the two counties. In the Gap Mills Section, page 231, its horizon is almost entirely concealed but there is an interval of 72 feet between the Oriskany Sandstone and Clinton Series and the Helderberg may occur in this place.

SUBDIVISIONS, HELDERBERG LIMESTONE.

In Maryland where the Helderberg Limestone has been intensively studied the following subdivisions in descending

order have been recognized by the Geological Survey of that State:

Becraft
New Scotland
Coeymans
Keyser.

In the Potomac region of West Virginia, as previously discussed by the writer in the Mineral and Grant County Report of the Survey, the Becraft member has almost entirely disappeared leaving only the lower three subdivisions, of which the upper or New Scotland member is largely composed of chert and carries a distinctive fauna, the underlying Coeymans being a thin and sandy limestone and the Keyser being a heavy bed of pure limestone.

In Mercer and Monroe Counties the few exposures of Helderberg noted are usually quite cherty and contain fossils of New Scotland age, making it probable that the Helderberg beds of this region are almost entirely New Scotland. It is possible, however, that the exposure at the Bluefield Fair-Grounds might reveal some beds of Coeymans or Keyser age if fully explored.

TOPOGRAPHIC EXPRESSION, HELDERBERG LIMESTONE.

The outcrops of Helderberg are so fragmentary that they show no distinctive topography except a slight depression between the Oriskany and Clinton, which may sometimes be noted in the almost vertical outcrops north of the St. Clair Fault.

AREAL EXTENT, HELDERBERG LIMESTONE.

In Mercer County the outcropping Helderberg appears to be confined to a strip less than one mile long starting at the line of Tazewell County, Virginia, near the entrance to the Bluefield Fair-Grounds and extending eastward into South Bluefield where the formation is covered by the St. Clair Fault. In Monroe County there appears to be another outcrop on the north side of Gap Mountain, starting about one

mile west of Gap Mills and crossing Second Creek at the northern edge of the gap, and possibly continuing northeastward to the line of Alleghany County, Virginia, although it was not noted in the latter region. The evidence for mapping this exposure is slender and based on its apparent presence in the gap of Second Creek, and more detailed studies might prove it to be absent in part of this territory. In Potts Valley it was not observed at any point.

CONTACTS, HELDERBERG LIMESTONE.

The upper contact of the Helderberg Limestone with the Oriskany Sandstone has already been discussed on previous pages in the discussion of the latter formation. Its base rests unconformably upon the Clinton Series of the Silurian, the entire Salina Formation and the Niagara Limestone being absent, as already stated.

FOSSIL LIFE, HELDERBERG LIMESTONE.

The exposure at the Bluefield Fair-Grounds contains marine fossils including crinoids and brachiopods of apparent New Scotland age, but unfortunately no list of its fauna is available since **Fossil Lot 39 on Map II,** which was collected by Dr. Prouty at the west end of the race-track, proved to have such a mixture of types on account of the faulting that its fauna was not considered of value.

CORRELATION, HELDERBERG LIMESTONE.

The relationship of the Mercer and Monroe County Helderberg to the exposures of the Potomac region in West Virginia, Maryland, and consequently to the more typical beds of New York, has already been mentioned on previous pages, the view being advanced that these beds are largely of New Scotland age. Their very poor exposure and limited extent do not warrant any further discussion of their age and stratigraphic associations.

DESCRIPTION OF MEMBERS, HELDERBERG LIMESTONE.

As already stated the local Helderberg appears to be New Scotland and hence the general description of the series, as already given, embraces the description of its members.

ECONOMIC ASPECTS, HELDERBERG LIMESTONE.

The slight exposures of the Helderberg do not lead to the belief that they could be exploited to any extent for commercial purposes since they are cherty and impure. It is possible that some stone for concrete aggregate might be quarried near the Bluefield Fair-Grounds and this would doubtless be done if other limestone was not available in the same region, but the unlimited quantity of both limestone and dolomite around the city minimizes any importance this local deposit of Helderberg might have.

CHAPTER XI.

STRATIGRAPHY---SILURIAN ROCKS.

INTRODUCTION.

As indicated in the General Columnar Section, pages 130-133, the Silurian Rocks of Mercer and Monroe Counties (there being no outcrops in Summers), have been classified as follows, in descending order, certain titles being herein added in parentheses to indicate supposed correlations that for various reasons do not seem entitled to first place:

	Thickness. Feet.	Total. Feet.
Clinton Series (Rockwood and Cacapon of United States Geological Survey Folios).	300 to 500	500
White Medina Sandstone (Tuscarora or Clinch of United States Geological Survey Folios)	50 to 150	650
Red Medina Series (Juniata or Bays of United States Geological Survey Folios and some other organizations)	300 to 400	1050
Gray Medina Sandstone (Oswego, Oneida? Shawangunk?, of various reports)	2 to 0	1050

It is evident from the above summary that these rocks vary in thickness from a minimum of about 650 feet to a possible maximum of 1050 feet. They appear to be completely exposed to view in Giles County, Virginia, a neck of which extends northward between Mercer and Monroe and includes the narrows of New River where many thousands of feet of strata are visible on account of their highly inclined position. On the east side of this gap, as recorded in the Rich Creek Section, page 209, the Silurian has a measured thickness of 957 feet, all of its series which were observed elsewhere in the region being included and the only doubt as to its full thickness being that the contact with the Devonian is not

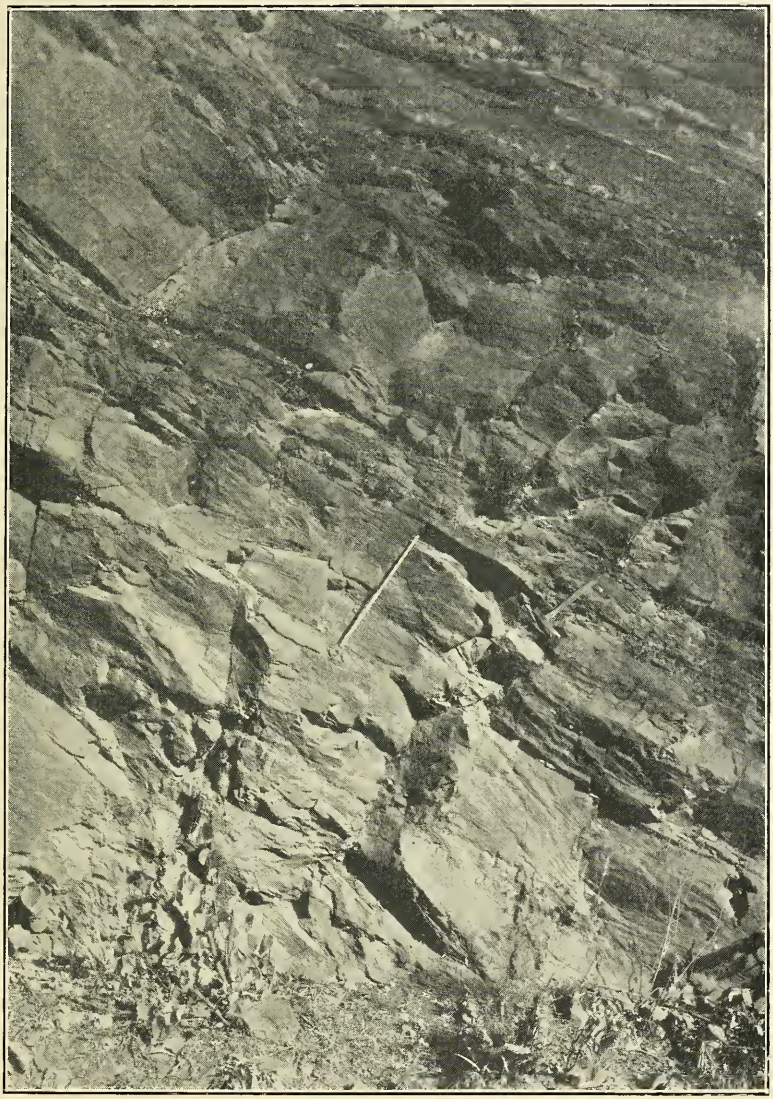


PLATE XXXI.—View of Silurian-Ordovician contact along highway on east side of New River, Giles County, Virginia, 1.3 miles north of Narrows. Beds above hammer and rule are Red Medina; two-foot rule covers almost entire thickness of Gray Medina. Beds below rule are Lower Maysville Group of Martinsburg and abundantly fossiliferous. See Rich Creek Section. (Photo. by Palmer & Fowler).

visible at the top of the section, since the top of the Clinton Series is overshot by older formations and also covered by Pleistocene material. From this section and from other exposures it is probable that 900 feet would be a fair average thickness for the Silurian of the local area.

In Mercer County the Silurian is further exhibited in part in the Bluefield Fair-Grounds Section, page 195, and in Monroe it is partly measured in the Gap Mills Section, page 231, and the Hanging Rock Section, page 234.

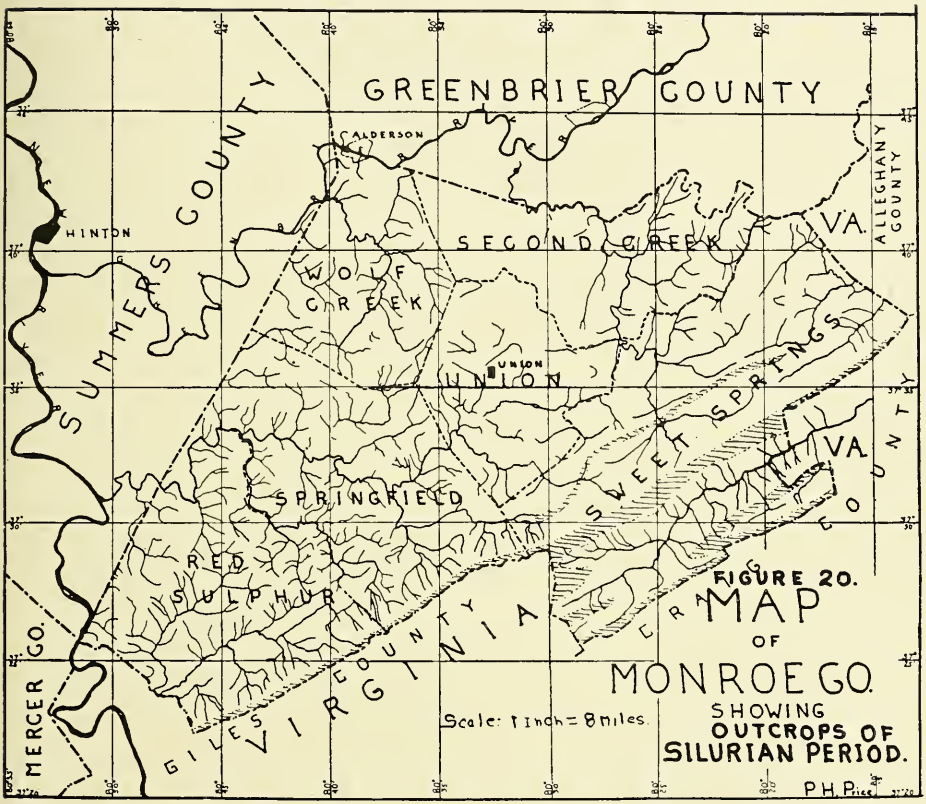
In a previous Report the writer[1] has lately reviewed the Potomac River phase of the West Virginia Silurian in relation to its type localities in New York and to its occurrence in intermediate States, its apparent southwestward thinning from more than 5,000 feet in eastern Pennsylvania to 3,000 feet or less in northern West Virginia being pointed out, and a general discussion of its correlation being included. In the local area it has further thinned to 900 feet, this figure being less than one-fifth of the total in eastern Pennsylvania and less than one-third of that for northern West Virginia. With this latter thinning across the State have disappeared, most happily, several formations on which there has been much controversy in Maryland, Pennsylvania, New Jersey, and New York, including the entire Salina Formation which embraces the Bossardville and Rondout Limestones and the Bloomsburg Series, as also the Niagara Limestone, and leaving the Clinton Series as its upper formation. It is apparent that no problems of the upper boundary with the Devonian need be discussed since the Clinton is clearly mid-Silurian in age and the somewhat empirical contact of the northern States has been replaced by a disconformity of first rank which may be termed an unconformity as well, although the junction between the two periods does not appear to be angular.

At the base of the Silurian the boundary question still remains. In previous Reports of the West Virginia Survey the Martinsburg has been considered the youngest portion of the Ordovician, all three of the Medinas being included in

[1]David B. Reger, Mineral and Grant Report, W. Va. Geol. Survey, pp. 357-377; 1924.

the Silurian. This usage has been followed in the present Report, there being some rather important local evidence on the subject as will later appear in the discussion of the various formations involved.

The local Silurian is almost entirely devoid of pure limestones, being mostly composed of quartzitic or ferruginous sandstones and red or sandy shales, with some deposits of iron ore that are closely confined to certain strata and with some pockets of manganese. In areal extent the rocks of the period are confined to narrow belts in the southern portions of Mercer and Monroe Counties, as is respectively shown by Figures 19 and 20, prepared by Price, and as indicated in more detail on Maps II and IV.



CLINTON SERIES.

GENERAL ACCOUNT, CLINTON SERIES.

The Clinton Series, comprising the upper portion of the Silurian in Mercer and Monroe Counties and including the ferruginous deposits down to the top of the White Medina Sandstone, is an assemblage of gray or white quartzites, olive-green, yellow, or reddish shales, and red sandstones heavily impregnated with iron. In the upper portion there is a quite persistent bed of red hematite long known as the "Fossil Ore Horizon", there being some local accumulations of low-grade manganese in close association with the iron. Near the base

of the series there is usually a massive sandstone ledge that is red and ferruginous but sometimes the iron is so nearly absent that the bed may be distinguished with difficulty from the closely underlying White Medina.

The olive-green shales that form the softer portions of the series are platy or fissile, argillaceous in part but more inclined to be sandy, there being included lenses of flaggy sandstone and a variable content of iron accounting for local differences in color. Marine fossils are often found in the Fossil Ore Horizon and occasionally in the shales, but are rare, or possibly absent, in the sandstones.

The thickness of the Clinton in the two counties appears to vary from 300 to 500 feet, there being few points at which it can be accurately measured because of the usual distortion of the strata. In the Bluefield Fair-Grounds Section, page 195, there is a total of 540 feet, but the lower portion is poorly exposed and it is not certain that the basal part is included, since the formation is suddenly smothered by the St. Clair Fault. In the Rich Creek Section, page 209, it measures 445 feet as exposed in the narrows of New River in the edge of Giles County, and is apparently all represented, although the upper member is covered by terrace gravel and the overthrust Ordovician so that the contact with the Devonian is not displayed. In the Gap Mills Section of Monroe County, page 230, it is 358 feet thick and seems to be all in place, but the lower part of the Devonian is concealed, making this contact somewhat uncertain.

SUBDIVISIONS, CLINTON SERIES.

In New York, where the Clinton was first studied by Vanuxem, Eaton, Hall, and others, its section is so different that it does not appear applicable to the West Virginia phase of the series, most of its limestones having disappeared in passing southwestward. In Pennsylvania, however, the subdivisions of H. D. Rogers, as made in 1858 and later revised by Dr. I. C. White[2], are as follows, in descending order:

[2] I. C. White, Report G7, pp. 111-112 (1883), and Report T3, p. 132 (1885); Sec. Geol. Survey of Pa.

Upper shales
Ore Sandstone and Fossil Ore
Middle shales
Iron Sandstone and **Block Ore**
Lower shales.

In Maryland, Swartz[3] has lately indicated a much different classification which is as follows:

Clinton Group:
Rochester Formation.
Upper shale and limestone
Roberts Iron Ore
Keefer Sandstone member
Rose Hill Formation
Upper shale beds with some purplish bands
Cresaptown Iron Sandstone
Lower shale and sandstone beds.

Of the above classification the Keefer Sandstone was named by Stose and Swartz[4] in the Potomac region of West Virginia and Maryland where it was put in the McKenzie Formation of the Cayuga Group, this formation being essentially the same as the Niagara Limestone of the various West Virginia Reports which deal with that region. In the Maryland Silurian volume, however, Swartz concludes that the Keefer Sandstone belongs at the base of the Rochester Formation, and furthermore, agrees with Ulrich that the Rochester is a constituent part of the Clinton as originally defined by Vanuxem at its type locality. In Mineral and Grant Counties of West Virginia the writer found no sandstone that could be definitely correlated with the Keefer, either in the Niagara or the Clinton as described in the Report on those two counties so that the work in that region gives no light on the question of its age.

In Mercer and Monroe Counties, however, the Clinton Series is nearly always capped by a massive, white and quartzitic sandstone, and Dr. Prouty, who has for many years studied

[3]Charles K. Swartz, Silurian Volume, Md. Geol. Survey, pp. 27-35; 1923.

[4]G. W. Stose and C. K. Swartz, Pawpaw-Hancock Folio, No. 179, U. S. Geol. Survey; 1912.

the Silurian of the Potomac region, agrees that this ledge should be correlated with the Keefer of the northeastern region. It would also appear to the writer that the Keefer Sandstone is much the same as the Ore Sandstone of Rogers and White which is detailed by the latter as coming just above the Fossil Ore Horizon. If that assumption be true it is then evident that the Roberts Iron Ore of Swartz is not the same as the Fossil Ore Horizon. In Mercer and Monroe a bed of fossiliferous ore was found below the Keefer Sandstone but none above it, leading to the belief that this southern bed is the true Fossil Ore Horizon of eastern Pennsylvania.

Farther down in the column there is little doubt that the Cresaptown Iron Sandstone of Swartz is the same as the Iron Sandstone of Rogers and White and it extends into northern West Virginia, as recorded in the Mineral and Grant Report and is easily recognized in the Clinton of the southern part of the State.

In making a classification of the Clinton of Mercer and Monroe Counties the writer is not at present inclined to accept without reserve the view that the original Rochester Shale of New York State should be classed with the Clinton, since Chadwick[5] who has made a careful study and review of the evidence in western and central New York, offers some very good evidence in contradiction of such an interpretation. It rather appears that these questions, in so far as they affect West Virginia, should be left open until the Silurian shall have been studied entirely across the State. It does appear reasonably sure that the massive quartzite near the top of the southern Clinton is much the same as the Keefer of the Potomac region and this may be provisionally adopted, since most authors now appear to be in agreement that it belongs in the Clinton although they are not in accord on the question of a possible correlation with any part of the New York Rochester.

Having in mind both the local phase of the beds and the above discussion, the Clinton of Mercer and Monroe Counties may be summarized as follows:

[5]G. H. Chadwick Stratigraphy of New York Clinton, Bull. Geol. Soc. Am., Vol. 29, pp. 327-368; 1918.

Upper shales (mostly absent)
Keefer Sandstone
Fossil Ore Horizon
Middle shales (including another white quartzite)
Iron Sandstone
Lower shales (mostly absent).

TOPOGRAPHIC EXPRESSION, CLINTON SERIES.

The local outcrop of the Clinton is entirely confined to regions where the strata have been much disturbed by sharp folds which in some cases have become overturns or faults and this circumstance, together with the presence of heavy and highly resistant sandstones, makes the Clinton topography extremely rugged. As a rule, however, it does not form ridges or escarpments, these being generally made by the underlying White Medina while the Clinton forms two or three successive reefs along slopes where the beds are overturned, or a like number of distinct steps along slopes where the beds are normal but still sharply dipping. Smooth slopes and valleys do not appear to be made at any locality. Plates XXVI and XXVII illustrate in part the Clinton topography.

AREAL EXTENT, CLINTON SERIES.

In Mercer County the Clinton outcrop is mostly confined to a narrow wedge, less than one mile long, occurring on the northern side of the St. Clair Fault and being just west of South Bluefield next to the line of Tazewell County, Virginia. Here the beds are overturned and now dipping southward, their cross-section being partly visible in the gap of Beaver Pond Creek. Farther east there is another very small area on the top of East River Mountain at the sharp offset of this ridge about three-fourths mile north of Buckhorn Knob where a shallow basin, starting on the head of Pigeon Creek and passing westward into Virginia, is covered by the Iron Sandstone and some of the overlying shales.

In the edge of Giles County, Virginia, the Clinton is well exposed on the east side of New River in the narrows, this being the most convenient point for its study in the local region.

In southwestern Monroe it is entirely covered by the St. Clair Fault for many miles but on Dropping Lick Creek just west of Zenith it emerges from this overthrust and its very narrow and mostly overturned outcrop then passes northeastward to Crimson Springs, then turns nearly northward, crossing Turkey Creek 0.7 mile east of McGlone, after which it gradually veers northeastward again and follows along the northern slope of Gap Mountain to Second Creek where it is visible in the gap just north of Gap Mills. East of Second Creek it continues for several miles along the northern side of Gap Mountain but gradually rises higher on the mountain until it forms the crest in the region west of High Head Mountain and apparently so continues until it again passes under the St. Clair Fault about due north of Coakesbury Church.

In Potts Valley of Monroe County there is an area of Clinton, 12 miles long and one-half to three-fourths mile wide, lying high up on the southern slope of Peters Mountain; and at the western edge of the county, next to Giles, this outcrop is continuous southward across the North Fork Syncline and makes the summit and most of both slopes of Fork Mountain. Farther south and southwest of Waiteville, in the intricately folded and somewhat obscure southern end of the county, it covers Little Mountain and the Back Valley Anticline for 2½ miles next to the Giles County line and also forms most of the Crosier Anticline along or near Potts Mountain and next to the Craig County line, there being a brief strip of White Medina on the rising axis toward the western end. In this part of the county, south of Little Mountain and west of Crosier Branch, however, some of the critical localities show no natural outcrops, being covered entirely by debris so that the formation boundaries on Map IV must be regarded as only approximate.

Farther east in southern Monroe the Clinton makes another long and narrow outcrop, starting on the northern slope of Little Mountain at the Craig County line two miles southeast of Laurel Branch and passing southwestward 5½ miles to Wilson Branch of Potts Creek where it then turns south-

ward across the Back Valley Anticline and returns eastward, being first on the southern slope of Potts Mountain, then on its summit and finally on its northern slope until it finally enters Craig County just north of Nicholson Knob.

CONTACTS, CLINTON SERIES.

The upper boundary of the Clinton has already been discussed in connection with the Oriskany and Helderberg, with mention of the fact that several of the upper divisions of the Silurian are entirely absent in all the local territory, along with all or part of the Helderberg of the Devonian in a considerable part of it. The base of the Clinton rests upon the White Medina Sandstone, the lower shales of the Clinton being generally absent. At this boundary it is not apparent that any large hiatus exists but there is evidence of diastrophic action since the Medina is essentially a strand formation, its organic remains in the local territory being confined to **Arthrophycus** and **Scolithus,** the affinites of which are little known, while the Clinton is all definitely, and several zones abundantly, marine.

FOSSIL LIFE, CLINTON SERIES.

Marine fossils are quite common in the Clinton Series, being found in some abundance at the Fossil Ore Horizon in localities where that member has not been too much metamorphosed, and being also present in the shales and occasionally in the Iron Sandstone. In Mercer County they are visible in the gap of Beaver Pond Creek south of the Bluefield Fair Grounds and also on the crest of East River Mountain north of Buckhorn Knob, although the latter locality is too difficult of access to be worth while as a collecting ground. In the narrows of New River **Fossil Lots 33, 34, 35, 36, and 37 on Map II** were collected by Dr. Prouty and the writer. Of these, **Lot 37** is in the Fossil Ore Horizon and the remainder in the middle shales coming between the ore and the Iron Sandstone. **Lot 33,** unfortunately, was lost in transit, but the re-

maining lists, as detailed by Dr. Prouty, are published in the Rich Creek Section, page 209.

In the Gap Mills Section, page 231, there are fossils in the middle shales but no collections were made. **Fossil Lot 59 on Map IV,** collected by Dr. Prouty and the writer in Potts Valley in the gap of Ewin Run through Little Mountain and consisting of some loose boulders which had rolled down the mountain, contains, according to Dr. Prouty, **Tentaculites minutus** Hall, **Calymene clintoni** Vanuxem, and **Zygobolba** cf. **emacerata** U. &. B. Two other collections, both of which are in the Fossil Ore Horizon, will be detailed under the description of that member on later pages.

CORRELATION, CLINTON SERIES.

The relationships of the Clinton Series of the two counties to its more northeastern counterparts in other States have already been discussed under the subject of "Subdivisions", the view being stated that it is inadvisable to make many detailed comparisons in the present Report. In addition to certain apparent correlations therein pointed out, however, it is also evident that the main body of the Clinton above the Iron Sandstone corresponds in large part to the Rockwood Formation of Tennessee, as named there by the United States Geological Survey and as so described in many of its Folios on the southern Appalachian States; and also that the Iron Sandstone is quite the same as the Cacapon Sandstone of the Potomac region, as so called by the United States Geological Survey.

DESCRIPTION OF MEMBERS, CLINTON SERIES.

UPPER SHALES.

The upper shales of the Clinton, coming above the Keefer Sandstone and the Fossil Ore Horizon, do not appear to be present at most localities in Mercer and Monroe. In the Bluefield Fair-Grounds Section, page 195, there is a concealed interval of 160 feet above the Keefer Sandstone, with frag-

ments of red sandstone and shale and with marine fossils. If the Keefer Sandstone is properly identified the material above it naturally belongs to the upper shales. Elsewhere no such thickness was observed.

KEEFER SANDSTONE.

The **Keefer Sandstone,** named in the Potomac region as previously noted, is a gray, hard, and quartzitic bed, with numerous quartz pebbles, belonging nearly always at the top of the Clinton in Mercer and Monroe Counties, and having a thickness of 25 to 100 feet. In Mercer it is noted in the Bluefield Fair-Grounds Section, page 195, as 115 feet thick, but being covered by a thickness of the upper shales as above mentioned. In the Rich Creek Section, page 209, it is recorded as 100 feet thick but as apparently split into two ledges, the intervening shale being too poorly exposed for study. This exposure is on the east side of the narrows of New River and easily accessible.

In Monroe County it is visible in the gap of Second Creek north of Gap Mills, as recorded in the Gap Mills Section, page 231, being white, quartzitic, and 55 feet thick. In Potts Valley it is probably this sandstone which outcrops in the edge of Craig County, Virginia, on the Peters Mountain road 2½ miles northeast of Paint Bank, at elevation 2745′ B. On Paint Bank Run, in the same county one mile south of Paint Bank, there is a white quartzite 30 to 35 feet thick and standing nearly vertical that appears to be the Keefer. On the south slope of Peters Mountain, 0.7 mile northward from Laurel Branch, Monroe County, it is 50 feet thick, massive, and quartzitic, at elevation 3020′ B., as detailed in the Local Measurement at **Fossil Lot 67 on Map IV** on a later page. On the south slope of Fork Mountain east of the Giles County line it makes a prominent shoulder. On Crosier Branch 1¼ miles southwest of Waiteville and slightly south of the Norfolk and Western Railway, it has a visible thickness of about 30 feet, the dip being northward at the rate of 50 degrees. In Craig County it is exposed in the road on the south side of the

summit of Potts Mountain and one-half mile southeast of Ray, being soft and apparently level, with its top at elevation 2920′ B., and with a visible thickness of 30 feet. Farther east along the same mountain 1.3 miles east of Ray it makes the top of the mountain at elevation 3315′ B., being 40 feet thick and dipping southward at the rate of 40 degrees and having some streaks of iron. On the south slope of Potts Mountain 1¼ miles southwest of Arnold Knob it is visible at elevation 3540′ B., the dip being northward.

FOSSIL ORE HORIZON.

The **Fossil Ore Horizon,** as previously mentioned under the subject of "Subdivisions", is a generally ferruginous deposit, consisting of shales and sandy material from which some original calcareous material may have been leached, its position being just beneath the Keefer Sandstone and its thickness ranging from 5 to 25 feet of which the iron-bearing strata are only a part. In regions where it has not been excessively metamorphosed it usually contains abundant marine fossils. In the Rich Creek Section, page 209, it occurs as thin beds of siliceous iron ore coming within 60 feet of shale and carrying a considerable marine fauna from which **Fossil Lot 37 on Map II** was collected by Dr. Prouty and the writer, the list of which, as determined by the former, is contained in the Rich Creek Section. The following exposure was noted in Potts Valley of Monroe County:

Local Measurement at Fossil Lot 67.

Sweet Springs District, Monroe County; on south slope of Peters Mountain along highway between Gap Mills and Laurel Branch and 0.7 mile northward from latter point; dip, southeastward 20 degrees; arrangement in descending stratigraphic order; starts at top of Clinton Series.

	Thickness. Feet.	Total. Feet.
Clinton Series (65′)		
1. **Sandstone, Keefer,** massive, quartzitic (base at 3020′ B.)	50	50
2. **Sandstone, Fossil Ore Horizon,** ferruginous, with thin beds of shale and thin zones of marine fossils. **Lot 67;** contains **Tentaculites minutus** Hall, **Zygobolba** close to **carinifera** U. & B., **Orthoceras** sp., **Calymene** sp.	15	65
3. Shale, yellow, sandy	..	..

At the above locality **Fossil Lot 67 on Map IV** was collected by the writer, the fauna being as indicated by Dr. Prouty. Another collection, **Fossil Lot 136 on Map IV,** was collected by the writer at elevation 3280′ B. on the south side of Fork Mountain 3.6 miles S. 75° W. of Waiteville, the fauna being reported by Dr. Prouty as **Calymene clintoni** Vanuxem and **Orthoceras** sp. At this locality the horizon is quite ferruginous but the Keefer Sandstone does not extend so far up the mountain.

The Fossil Ore Horizon in southern Monroe contains some valuable deposits of iron ore, as well as occasional impregnations of manganese, the quality and quantity of which are not so certain. These ores will be described at some length in Chapter XV.

MIDDLE SHALES.

The middle shales, with a thickness varying from 175 to 250 feet and composed of yellow, green, or reddish-brown shales, fill up the interval between the Fossil Ore Horizon and the Iron Sandstone. The fossil content of the middle shales is exhibited in the Rich Creek Section, page 209, as previously mentioned in this Chapter under the subject of "Fossil Life". In Potts Valley there is a white quartzite in this portion of the series, there being an exposure on the top of Potts Mountain 1.2 miles southwest of Arnold Knob at the point where the State line turns suddenly southward. Here this quartzite forms the top of the ridge at elevation 3755′ L., its dip being southward at the rate of 43 degrees. Northward down the mountain the reddish Iron Sandstone underlies it by an interval of a few feet, followed in turn by the White Medina. This apparently undescribed quartzite in the Clinton contains **Scolithus** rods and might easily be mistaken for the Medina. It is not herein named because of the almost inaccessible locality where it was found and because of the lack of a more detailed section. It also outcrops in the Elliber Field about one-half mile east of the corner of Monroe, Craig, and Giles Counties and thence extends westward to the "White Rocks" at the corner.

IRON SANDSTONE.

The **Iron Sandstone,** already mentioned under the subject of "Subdivisions" on page 583, is a massive, reddish-brown and generally ferruginous ledge varying in thickness from 25 to 75 feet and usually coming only a few feet above the base of the series in the local area. In Mercer County the presence of this ledge in the Clinton exposure on Beaver Pond Creek south of the Bluefield Fair-Grounds is not certain, although there are fragments of such rock on the southern end of the ridge next to the St. Clair Fault. Farther east it is visible on the top of East River Mountain about three-fourths mile north of Buckhorn Knob in a basin which starts there and runs westward into Virginia. In the narrows of New River in Giles County, Virginia, it is recorded in the Rich Creek Section, page 209, being there 20 feet thick, slightly ferruginous, and making the extreme base of the series.

In Monroe County it is visible in the gap of Second Creek just north of Gap Mills, as recorded in the Gap Mills Section, page 231, being red, ferruginous, and 70 feet thick and coming just above the White Medina. In Potts Valley it is visible on the southern slope but near the top of Peters Mountain 0.8 mile east of Hanging Rock, its visible thickness being 15 feet, the elevation of its top 3395′ B., and its dip southward at the rate of 25 degrees. It may generally be found on this mountain just south of the crest. On Potts Mountain it is visible in Craig County, Virginia, at the summit of the new road which ascends the mountain from Back Valley and reaches the top at the same point as the old, steep road, three miles southward from Paint Bank. On the same mountain farther west it is visible just north of the summit of the ridge 1.2 miles southwest of Arnold Knob, its position being between the White Medina Sandstone which occurs a little farther down the mountain and toward the north and the unnamed quartzite which there forms the top of the ridge as previously described. On Potts Mountain 0.8 mile east of Ray it forms the top of the ridge at elevation 3175′ B., with a southward dip of 30 degrees, being red and ferruginous, with an unknown

thickness. On the same mountain its boulders are again visible at the Elliber Field, which is a cleared spot about one-half mile east of the common corner of Monroe, Craig, and Giles Counties, their elevation being 3625′ B., and their position being north of and therefore below a white quartzite which is prominent along this part of the mountain and which evidently belongs in the middle shales somewhat below the Fossil Ore Horizon.

Although the Iron Sandstone at times contains a considerable amount of iron it is not apparent that these impregnations have much of a commercial value, since the percentage is usually low and the siliceous base would make the recovery of the metal quite expensive. An analysis will be found under the subject of "Iron Ore" in Chapter XV.

LOWER SHALES.

The lower shales coming between the Iron Sandstone and the top of the White Medina appear to be absent at most points north of Peters Mountain but in Potts Valley there is sometimes an interval of a few feet that represents them. No observation of sufficient accuracy to determine their thickness or character was obtained in this much disturbed region.

ECONOMIC ASPECTS, CLINTON SERIES.

In the Fossil Ore Horizon of the Clinton there is a very considerable amount of iron ore, particularly in Potts Valley. The available evidence on these deposits, together with chemical analyses and estimates of tonnage, will be found in Chapter XV under the subject of "Iron Ore". These deposits at times contain variable amounts of manganese which may not be of commercial value at present but which will also be discussed in Chapter XV. The sandstones of the Clinton are very hard and durable and if built into structures would be almost everlasting but there is little likelihood that they could be split and dressed into desired shapes on account of their tough character. The Iron Sandstone has a very pleasing

texture and usually weathers into rectangular blocks enough of which might be found at some localities to build bungalows or other small buildings. If once erected such buildings would be highly attractive to the eye. The shales of the series do not appear to be of much value but there may be a few localities where they could be utilized for brick manufacture as is done at Cumberland, Maryland. In general however, they appear to have too many lenses of sandstone to make them wholly desirable for such a purpose.

WHITE MEDINA SANDSTONE.

GENERAL ACCOUNT, WHITE MEDINA SANDSTONE.

The White Medina Sandstone, coming just below the Clinton Series and at the top of the three Medina formations, is a mass of white quartzite varying in thickness from 50 to 150 feet, and containing few, if any, perceptible inclusions of shale. It is nearly always extremely hard and at some localities is so much metamorphosed that it gives the impression of a monolithic silicate, but at other points the sand grains are quite distinct, with large pebbles of pure quartz standing out in relief from the matrix. In Mercer County it is found only on the extreme summit of East River Mountain along the Virginia line but in the narrows of New River, in Giles County, Virginia, it is visible on both sides of the river, being recorded as 120 feet thick in the Rich Creek Section, page 210. In Monroe County it is noted in the Gap Mills Section, page 231, as 110 feet thick and in the Hanging Rock Section, page 234, it has a visible thickness of 60 feet in the top of Peters Mountain, but probably is not all exposed.

TOPOGRAPHIC EXPRESSION, WHITE MEDINA SANDSTONE.

The outcrop of the White Medina Sandstone is marked at nearly all points by rugged topography, the ledge being so very hard and durable that it apparently withstands weathering better than any other stone in the local area and so is the

predominant factor in preserving the high mountain ridge along the southern border of Mercer County and the great mountains of southern Monroe. East River Mountain at the southern edge of Mercer is a good example of the ridges formed by this sandstone, and Peters Mountain, which is only a northeastward continuation of the same ridge into Monroe County, is mainly covered by its protective mantle. The length of these two ridges across Mercer and Monroe Counties, including the narrow strip of Giles County, Virginia, which comes between them, is approximately 62 miles, but the entire length of the escarpment is still greater since it extends southwestward about 10 miles into Tazewell County, Virginia, and also northeastward into Alleghany County, where the outcrops have never been mapped. In all this distance of 70 or 80 miles New River is the only stream which has cut a channel through the ridge. Along these two mountains, as well as at various other outcrops in southern Monroe, the White Medina usually makes an escarpment sloping southward beneath younger formations and littering the northern front of the mountains with vast quantities of large boulders. Plate I shows a view of East River Mountain and Plate XXVIII a portion of Peters Mountain, while Plates XXVII and XXX show more detailed occurrences of the White Medina.

AREAL EXTENT, WHITE MEDINA SANDSTONE.

As shown by Map II the only outcrop of White Medina in Mercer County is along East River Mountain next to Bland and Giles Counties, Virginia. In Monroe County, as shown by Map IV, its most northern outcrop emerges from beneath the St. Clair Fault south of Dropping Lick Creek and one-half mile southwest of Zenith, passes northeastward to Crimson Springs, and thence nearly northward across Turkey Creek to the summit of Gap Mountain, which it follows northeastward, crossing through the gap of Second Creek just north of Gap Mills and continuing 6½ miles farther to a locality one mile east of High Head Mountain where it disappears

beneath the fault. This whole outcrop is overturned, the dip being southeastward, and the width of the exposure quite narrow and little more than the thickness of the formation.

Its outcrop in Peters Mountain has already been mentioned. This outcrop is also narrow, since the southward dip soon covers it with younger rocks. In Potts Valley the White Medina enters Monroe County from Craig County, Virginia, at the crest of Little Mountain about 1½ miles southeast of Linton, and passes southwestward with this ridge for 7 miles, being cut in two by Trout Branch and being sharply overturned. Another outcrop enters Monroe from Craig County at Nicholson Knob and then follows Potts Mountain southwestward 6½ miles until it joins with the exposure just above described but is not overturned. These two outcrops form the north and south limbs of the Back Valley Anticline, the axis of which dips to the southwestward. Another brief exposure occurs along the Crosier Anticline next to Giles County.

CONTACTS, WHITE MEDINA SANDSTONE.

The upper boundary of the White Medina has already been discussed in the description of the overlying Clinton Series. Its base rests upon the red and variegated shales and red sandstones of the Red Medina Series, the lithologic change between the two being quite pronounced. This has been regarded by many authors as the proper boundary between the Ordovician and Silurian Periods but there appears to be little evidence in West Virginia that would support such a view, and the change in lithology is probably due to diastrophism. On East River Mountain south of Bluefield the White Medina contains **Arthrophycus alleghaniensis** and in the Red Medina what appears to be a form of **Arthrophycus** also occurs. The survival of such a peculiar organism across a time break of primary rank would not be probable, and besides, it has always been considered a Silurian fossil.

FOSSIL LIFE, WHITE MEDINA SANDSTONE.

Fossil life in the White Medina appears to be wholly represented by occasional displays of **Arthrophycus alleghaniensis** and **Scolithus verticalis,** both of which occur in the local area and are found in the same ledge in other Appalachian States. **Fossil Lot 4 on Map II** on East River Mountain in the edge of Bland County, Virginia, 2½ miles southeast of Bluefield, collected by Dr. Prouty and the writer, contains **Arthrophycus alleghaniensis** Harlan, and **Scolithus verticalis** Hall, as identified by Dr. Prouty. **Scolithus** is also visible in the exposure on the east side of the narrows of New River and **Arthrophycus** was noted at Gap Mills, Monroe County.

CORRELATION, WHITE MEDINA SANDSTONE.

The White Medina Sandstone appears without doubt to be the same as the Tuscarora of various folios of the United States Geological Survey and certain other reports, and is the same as the Clinch Sandstone of Virginia and other southern Appalachian States. The correlation of these formations with the White Medina of New York, which was described at a much earlier date, appears to be reasonably certain and hence the original title is herein used.

ECONOMIC ASPECTS, WHITE MEDINA SANDSTONE.

The White Medina Sandstone, although very hard and durable, has not been valued as a building stone because it can scarcely be split into blocks or dressed with common tools. It contains a high percentage of silica but its use as glass-sand would be precluded by its quartz pebbles and by the cost of quarrying, crushing, and melting a rock of such nature. It does not form agricultural soil and contains no minerals of present known value.

RED MEDINA SERIES.

GENERAL ACCOUNT, RED MEDINA SERIES.

The Red Medina Series, coming just under the White Medina Sandstone and just above the Gray Medina Sandstone when that formation is present but otherwise lying upon the Martinsburg Series, is an assemblage of predominantly red sandstone and red shales. The sandstones are usually flaggy and shaly, making no ledges of any extent along the mountains although they are sufficiently durable to show ragged edges in some of the gaps. The shales are often quite siliceous and frequently have thin streaks of pale-green color along with the red. The whole series appears to vary from 300 to 400 feet in the local area, being probably within these limits on East River Mountain south of Bluefield, Mercer County, although the exposures are hardly of such a nature as to make an accurate measurement possible. In the narrows of New River in the edge of Giles County it is 390 feet, as noted in the Rich Creek Section, page 210. In Monroe County its visible thickness at Gap Mills is 330 feet, as recorded in the Gap Mills Section, page 231, but the basal portion of its overturned beds abuts against the St. Clair Fault and some of it may be cut off. In the Hanging Rock Section, page 234, it was poorly exposed but was roughly measured as 360 feet. The observed thicknesses are hardly half as much as those which occur in the Potomac region of northeastern West Virginia where it varies from 700 to 1100 feet. There is no evidence available to show which portion of the series is absent in southern West Virginia.

SUBDIVISIONS, RED MEDINA SANDSTONE.

Little or no attempt at subdividing the Red Medina into subordinate members has been made, even in regions where the formation is thicker and the exposures better than in Mercer and Monroe Counties, since the sandstones appear to be lenticular and there are no peculiar types of shale which may

be recognized from place to place, and it is seldom that organic remains are found. Under such conditions, or until more data have been obtained, it is necessary to treat the whole series as a single formation.

TOPOGRAPHIC EXPRESSION, RED MEDINA SERIES.

In most localities of the two counties where the Red Medina Series outcrops it lies just beneath a bold escarpment formed by the White Medina Sandstone and usually weathers to a smooth, steep slope without perceptible benches or outcropping ledges of consequence, but this slope is generally covered by vast quantities of debris from the White Medina. In a few instances where the rocks are now overturned the Red Medina occupies a position above the White Medina or possibly adjoins it in a somewhat vertical manner, and in such cases its topography becomes somewhat rounded. Plates XXVIII, XXX, and XXXI afford various views of this formation.

AREAL EXTENT, RED MEDINA SERIES.

In Mercer County the Red Medina makes a continuous outcrop on the northern slope and near the top of East River Mountain, starting at the Tazewell County line, south of Bluefield, and extending northeastward to the Giles County line, south of Glenlyn, and passing across the northern end of Giles County through the narrows of New River. It enters Monroe County on the northern slope of Peters Mountain, being just beneath the rim rock of White Medina, and then passes northeastward in this relationship until it goes into Alleghany County, Virginia, east of Sweet Springs. Farther north in Monroe County another outcrop comes from beneath the St. Clair Fault east of Crimson Springs and about three-fourths mile east of McGlone, as shown by Map IV, passing nearly northward for about one mile, then turning northeastward along the southern slope, but near the top of Gap Mountain, and so continues across Second Creek at Gap Mills and still farther northeastward along the same mountain until it again

goes under the fault in the region east of High Head Mountain. This outcrop is overturned through most of its length.

In Potts Valley the Red Medina enters Monroe from Craig County, Virginia, just south of the summit of Little Mountain about 1½ miles southward from Linton, passes southwestward, crossing Trout Branch near its forks and continuing in the same direction about three more miles, this being the northern and overturned limb of the Back Valley Anticline. Another exposure on the southern side of this anticline enters Monroe County from Craig County on the northern slope of Potts Mountain north of Nicholson Knob and passes southwestward about six miles until it joins with the outcrop just above described, along the descending axis of the anticline. The outcrops in both counties are all very narrow on account of the steeply dipping beds.

CONTACTS, RED MEDINA SERIES.

The upper boundary of the Red Medina with the White Medina has already been discussed in the description of the latter formation on previous pages. Its base belongs just above the Gray Medina Sandstone of Silurian age and this is apparently the relationship in the narrows of New River where these beds are fully exposed. Elsewhere in the two counties the Gray Medina was not observed and is probably absent at most localities, in which case the Red Medina rests upon the Lower Maysville Group of the Martinsburg Series of Ordovician age, there being an unconformity which is measured by the absence of the Gray Medina of the Silurian and by certain important beds which comprise the Upper Maysville Group in Ohio, Kentucky, and elsewhere, and possibly by the further absence of the Richmond Series which, however, is correlated with the Red Medina by some authors. In addition to these missing formations there occurs also the general time break that is always inferred at the Silurian-Ordovician boundary.

FOSSIL LIFE, RED MEDINA SERIES.

The Red Medina Series in the local area appears to be almost wholly devoid of organic remains, but at **Fossil Lot 5 on Map II,** which was collected by Dr. Prouty and the writer on East River Mountain south of Bluefield, there are some scanty forms which Dr. Prouty notes as **Arthophycus?,** worm borings, and **Lingula** close to **nicklesi.** Elsewhere in the two counties nothing of the kind was observed.

CORRELATION, RED MEDINA SERIES.

The Red Medina Series appears to be the same as the Juniata of various folios of the United States Geological Survey and the same as the Bays Sandstone of Folio No. 26, a part of which embraces territory in Mercer County. It is also considered by some authors as a non-marine phase of the Richmond Beds of Kentucky, Ohio, and Indiana, but this latter correlation is not herein affirmed.

ECONOMIC ASPECTS, RED MEDINA SERIES.

The Red Medina of the local area apparently contains little material that is of present known economic value. Its sandstones are all too shaly to be used for building stone and its red shales are generally so mixed with lenses of sandstone that they could hardly be used for brick material. No deposits of minerals were observed in the formation at any point. Presumably the weathered outcrop of the series would make a thin agricultural soil if free from external influence, but as a matter of fact it is nearly always covered by great masses of broken rock from the White Medina so that it is little more than waste land.

GRAY MEDINA SANDSTONE.

GENERAL ACCOUNT, GRAY MEDINA SANDSTONE.

The Gray Medina Sandstone coming just below the Red

Medina Series and lying just above the Martinsburg Series of Ordovician age appears to be almost wholly absent in the local area, the single observed exception being in the edge of Giles County, on the east side of the narrows of New River, as recorded in the Rich Creek Section, page 210, where there is a distinct gray sandstone only 2 feet thick, coming just below the red beds of the Red Medina and lying just above the abundantly fossiliferous Lower Maysville Group of the Martinsburg. This sandstone is quite different in lithologic appearance when compared with the two adjacent formations, and it also holds some fragments of black chert at the base in further evidence of a possible unconformity. It resembles the Lower Maysville more than it does the Red Medina but it lacks the marine fossils which always occur in great abundance to the very top of the Lower Maysville. It seems safe, therefore, to assume that this is a remnant of the Gray Medina Sandstone which has a thickness of about 250 feet in the Potomac region of northeastern West Virginia and which there occurs without marine fossils. Plate XXXI shows a very good view of the exposure in the narrows.

The Gray Medina in Pennsylvania has often been called the Oneida Conglomerate or "Gray Oneida", and this appears to be the present usage of New York State, although there is not agreement among all authors on this correlation. It also evidently corresponds in part with the Oswego of New York but the latter is now regarded as an overriding title inclusive of the Medinas in general. These correlations have been discussed at more length by the writer in the Mineral and Grant Report of the Survey in a region where they have more application than in the counties now under study.

The presence of the Gray Medina has not been indicated on Maps II and IV outside of the immediate locality of the narrows, because it was not elsewhere observed. Its horizon is often concealed, however, and it may be possible that other occurrences will be found along East River Mountain in Mercer and also in the outcrops of southern Monroe.

CHAPTER XII.

STRATIGRAPHY--ORDOVICIAN AND CAMBRIAN ROCKS.

INTRODUCTION.

The outcropping Ordovician and Cambrian Rocks of the local area consist primarily of calcareous beds, the total thickness of which varies from 5,000 to 6,000 feet. Of these deposits the upper 4,300 to 5,000 feet belong certainly in the Ordovician, while the lower 700 to 1,000 are probably Cambrian, judging from their lithology, there being no fossil evidence of any kind in substantiation of this belief.

Of the beds which are definitely classified with the Ordovician very good exposures are afforded for study in both Mercer and Monroe Counties, principally along the northern slopes and foot-hills of East River Mountain and Peters Mountain, as well as in the narrows of New River; and their general development compares favorably with other parts of the Appalachian region, there being a few formations absent as would be the case at almost any other locality. Sandstones and sandy shales are found only in the upper part, the remainder being composed of various calcareous types, including earthy or pure limestones and dolomites. Marine fossils are abundant in several of the subdivisions and appear to be wholly absent only in the Moccasin Limestone.

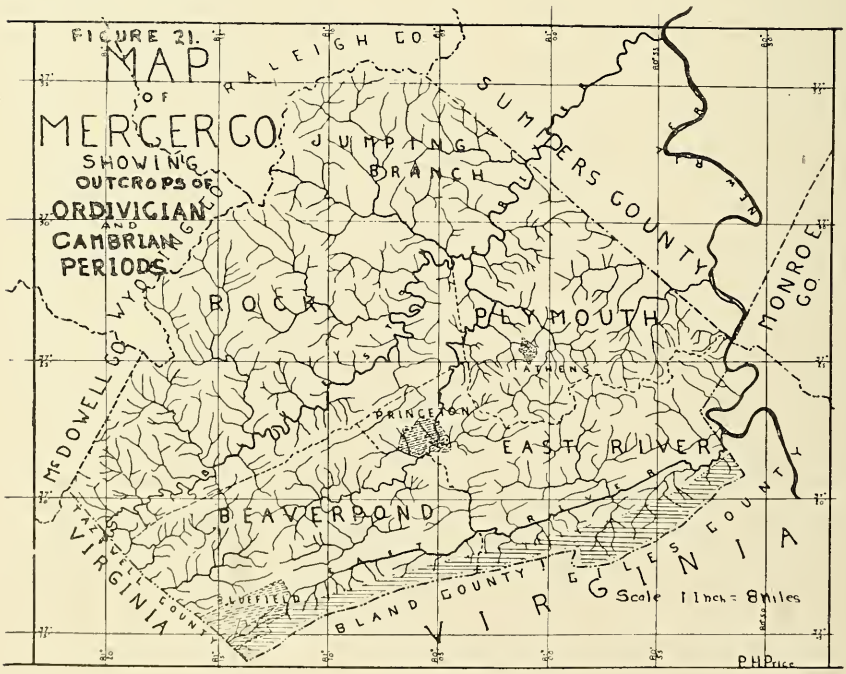
The formation which is tentatively considered to be of Cambrian age is a deposit of dolomite, having thin streaks of shale, some of which are tinged with red, but being barren of fossils so far as observed. Dr. Prouty thinks that this formation may be the Elbrook Limestone but has suggested

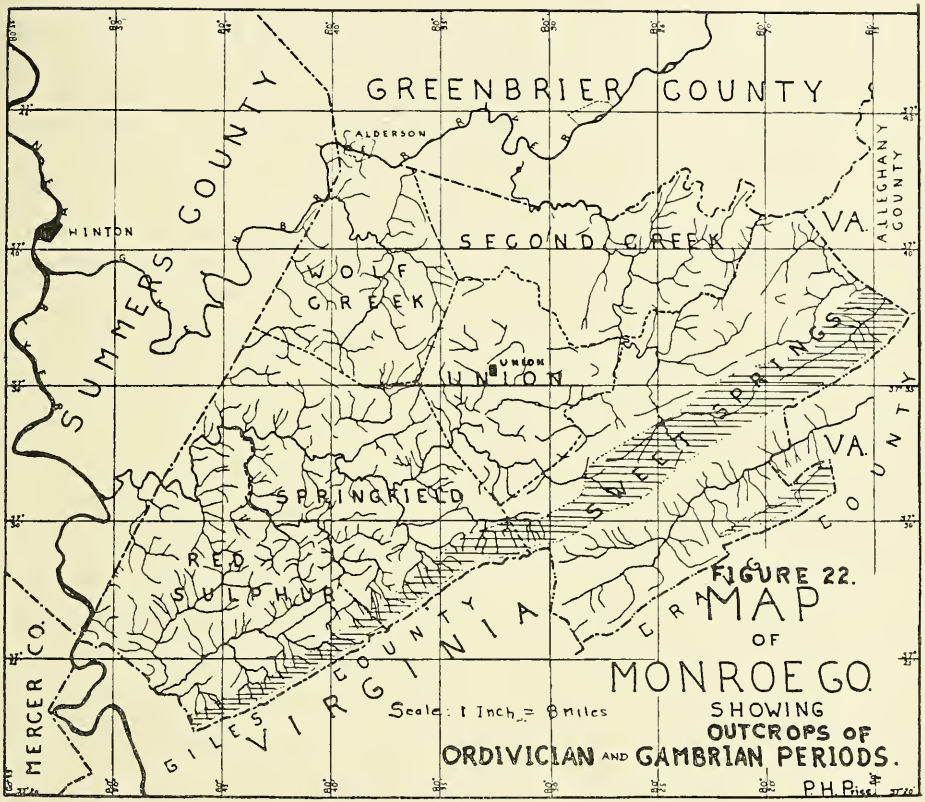
that it be mapped with the overlying Beekmantown Limestone which has accordingly been done.

The descending sequence of all these beds, as previously indicated in the General Columnar Section, pages 132-133, is as follows:

	Thickness. Feet.	Total. Feet.
Ordovician:		
Martinsburg Series (1300-1550')		
Lower Maysville Group	300 to 350	350
Eden Group	400 to 450	800
Trenton Group	600 to 750	1550
Moccasin Limestone	450 to 400	1950
Stones River (Chickamauga) Limestone	500 to 700	2650
Beekmantown Limestone	2000 to 2500	5150
Cambrian?		
Elbrook Limestone? (base not exposed).	700 to 1000	6150

Figures 21 and 22, prepared by Mr. Price, respectively indicate the outcrops of the above listed beds in Mercer and Monroe Counties, and Maps II and IV show them in much greater detail.





MARTINSBURG SERIES.

GENERAL ACCOUNT AND SECTION, MARTINSBURG SERIES.

The Martinsburg Series, comprising the upper division of the local Ordovician and coming below the Gray Medina Sandstone of the Silurian or below the Red Medina when the Gray is absent as is the case in most of Mercer and Monroe Counties, is an assemblage of friable sandstones, sandy or calcareous shales and flaggy, crystalline limestones, varying in thickness from 1300 to 1550 feet and carrying abundant marine fossils at nearly all horizons. The basal beds are almost purely calcareous, there being an upward gradation

into shales and sandstones. The limestones are blue or black, the flags being quite hard and often pure but interlaminated with sandy or calcareous gray shales. Higher in the series, where the limestone beds become infrequent or altogether disappear, the shales are yellow and often quite sandy with a well-defined triangular cleavage. The sandstones of the upper portion are brown, friable, and quite shaly with abundant marine fossils.

Opportunities for the study of this series are afforded at many localities, some of the exposures being nearly perfect. In the narrows of New River in Giles County, Virginia, the whole succession is displayed along the public road on the east side, there being only a few points where there is a covering of rubbish on some of the softer shales. Here the total is 1548 feet, as recorded in the Rich Creek Section, pages 210-11. Plates XXXI and XXXII show two views of these exposures. In Mercer County the fauna and lithology may be studied to good advantage on the new graded road which passes up East River Mountain south of Bluefield but a reliable measurement at this locality would hardly be possible. In Monroe the best exposure is on the north slope of Peters Mountain in the public road about three miles southwest of Gap Mills, the thickness, as noted in the Hanging Rock Section, pages 234-7, being 1345 feet.

In many previous reports the Martinsburg has been generally described as the Martinsburg "Shale", this being its original designation by Darton (Amer. Geol., Vol. X, p. 13) but it is apparent that the beds it contains, including sandstones, limestones, and shales, are entirely too complex to be embraced under such a simple title, hence it will be described as the **Martinsburg Series** in the present Report.

SUBDIVISIONS, MARTINSBURG SERIES.

On the basis of fossil determinations made by Dr. Prouty and with due regard to the lithology of the beds, the descending succession of the Martinsburg in the southern counties may be stated as follows:

	Thickness. Feet.	Total. Feet.
Lower Maysville Group: Composed of brown, friable sandstone and brown sandy shale, with abundant marine fossils throughout; **Lingula nicklesi Zone** at top; **Orthorhynchula linneyi Zone** near middle	300 to 350	350
Eden Group: Composed of yellow, argillaceous or sandy shales, with a little limestone in the upper part, but largely made up of blue, thin-bedded, crystalline limestones toward the base; abundant marine fossils...	400 to 450	800
Trenton Group: Blue, hard, crystalline, thin-bedded limestone, interlaminated with calcareous shales; abundant marine fossils	600 to 750	1550

Of the three major groups above noted, all of which will be discussed in more detail on later pages, the Maysville may be generally recognized by the presence of sandstone and the almost total absence of limestone, in addition to its distinctive fauna. Between the Eden and the Trenton, however, the distinction is largely paleontological, there being no reliable differences of lithology, although there is usually much more shale in the Eden than in the Trenton and the color of this shale is generally yellow instead of gray. The height at which limestone may be observed in the series varies greatly at different localities, being present entirely to the top of the Eden in the narrows region while at Bluefield the yellow shales extend down nearly to the top of the Moccasin Limestone, some of the Trenton being probably absent, and in Monroe County also there does not appear to be so much limestone in the Eden Group.

TOPOGRAPHIC EXPRESSION, MARTINSBURG SERIES.

Nearly all the outcrops of Martinsburg in the local area occur along mountains which are capped by the White Medina Sandstone and which are buttressed at the base by thick limestones and dolomites of Ordovician age, and of

varied resistive qualities. On such slopes the Martinsburg usually presents a smooth profile without benches or protuberances, as compared to the rather rough land formed by some of the adjacent series. Its sandstones are too soft to form ledges and its limestones and shales generally weather off to a smooth, steep slope.

AREAL EXTENT, MARTINSBURG SERIES.

In Mercer County the outcrop of the Martinsburg starts on the northern slope of East River Mountain at the line of Tazewell County, Virginia, south of Bluefield and follows northeastward in this position without deviation to the line of Giles County south of Glenlyn. In the narrows of Giles County it crosses New River 1.2 to 1.7 miles north of Narrows town, the strip being about one-half mile wide. It then passes northeastward along the northern slope of Peters Mountain, entering Monroe County near the head of Scott Branch southeast of Peterstown, and continuing in the same topographic relationship entirely across Monroe to the line of Alleghany County, Virginia, southeast of Sweet Springs. In all this distance of more than 60 miles the beds dip uniformly southward or southeastward at an angle that usually varies from 20 to 40 degrees.

In Potts Valley there is another outcrop of Martinsburg, approximately five miles long, occurring on the Back Valley Anticline in the region between Little Mountain and Potts Mountain, but being so much disturbed and faulted, as shown on Map II and Cross-Section FF′, as well as so much covered by debris that this locality is not a favorable one for the study of the series.

CONTACTS, MARTINSBURG SERIES.

The upper contact of the Martinsburg with the Gray Medina, or with the Red Medina in most of the local area, has already been mentioned in the discussion of these two formations of the Silurian. That there exists a considerable unconformity at this level seems open to little doubt but its

extent is unknown, not only on account of the general time break that is always assumed at the Ordovician-Silurian boundary but also because of the uncertainty that exists regarding certain correlations. It is evident that nearly all the Gray Medina is missing and apparently the upper part of the Maysville Group is also unrepresented. If it is true that the Richmond beds correlate with the Red Medina, as is affirmed by some authors, these latter are accounted for by a modified and largely non-marine series but if they should belong below all the Medinas and distinctly within the undisputed Ordovician they are entirely absent in the two counties.

The base of the Martinsburg rests upon the non-marine, earthy Moccasin Limestone which is an extensive non-marine formation throughout some of the southern Appalachian States and which according to various authors is probably of Chambersburg age, this being Dr. Prouty's idea as expressed in communications following a study of the Moccasin in the local area. Owing to the barren condition of the Moccasin Limestone it is not altogether evident whether an unconformity of any consequence may be here assumed, although it is safe to say that there was a pronounced diastrophic cycle which inserted the muddy, shoreward beds of the Moccasin into a prevailingly marine column. In some of the more southern States the Tellico Sandstone and Athens Shale, embracing 1000 to 1500 feet of beds, intervene between the Sevier (Martinsburg) and the Moccasin, but the Tellico is correlated as part of the Sevier by some authors while the Athens is sometimes indicated as part of the Sevier and sometimes as of older age. Whatever their age may be these formations do not appear in the local section.

The extreme base of the Martinsburg in the local area is marked by the presence of black, fissile, and slightly carbonaceous shale which appears to be a significant feature of the basal Trenton in its type locality in New York State and at other intermediate points in the northern Appalachians. The occurrence of such a zone in marked contrast to the overlying crystalline limestones and to the underlying red and earthy limestone makes a correlation plane of definite value.

it is slightly suggestive of the Black River beds but its interpretation as a remnant of this formation would hardly be justified.

FOSSIL LIFE, MARTINSBURG SERIES.

The Martinsburg abounds with fossil life throughout its whole succession, the faunas being rich and varied. In the Rich Creek Section, page 209, **Fossil Lots 22-32,** inclusive, on **Map II,** as collected by Dr. Prouty and the writer and as studied by the former, are specified in detail, and these collections embrace nearly all the series except the lower 400 feet. In the Hanging Rock Section, page 234, **Fossil Lots 71-98,** inclusive, **on Map IV** were collected by Dr. Prouty and the writer, their faunas being specified by Dr. Prouty in the section. These include all the basal beds from which collections were not made in the Rich Creek Section and also some of the higher zones.

In the new graded road which ascends East River Mountain south of Bluefield, Mercer County, **Fossil Lots 6-11,** inclusive, **on Map II** were collected by Dr. Prouty and the writer in descending succesion across the series which is there mostly composed of yellow shale. The identification of these fossils by Dr. Prouty is as follows:

Lot 6 (near top of series).—**Rafinesquina alternata** Emmons, **Calymene senaria** Conrad, **Zygospira modesta** (Say) Hall, Bryozoa.

Lot 7 (Lower than Lot 6).—**Plectambonites sericeus** Sowerby (aa), **Zygospira modesta** (Say) Hall (aa), **Zygospira modesta** var. **cincinnatiensis** James, **Pholidops cincinnatiensis** Hall (aa), **Rafinesquina alternata** Emmons (cc), **Calymene senaria** Conrad (c), **Isotelus** sp., **Proetus** cf. **latimarginata, Liospira** cf. **micula, Dalmanella testudinaria** Dalman, **Rafinesquina alternata fracta** Meek.

Lot 8 (Lower than Lot 7).—**Rafinesquina alternata fracta** Meek, **Zygospira modesta** (Say) Hall (aa), **Pholidops cincinnatiensis** Hall (a), **Diplograptus** cf. **vespertinus** Ruedemann, **Plectambonites sericeus** Sowerby, **Dalmanella multisecta** Meek.

Lot 9 (Lower than Lot 8).—**Rafinesquina alternata** Emmons, **Plectambonites sericeus** Sowerby (a), **Pholidops cincinnatiensis** Hall (a), **Zygospira modesta** (Say) Hall, **Dalmanella** cf. **testudinaria** Dalman.

Lot 10 (Lower than Lot 9).—**Pholidops subtruncatus** Hall (aaa), **Isotelus maximus** Locke, **Ceraurus pleurexanthemus** Green (aaa), **Isotelus gigas** DeKay, **Calymene** cf. **senaria** Conrad, **Rafinesquina alternata** Emmons, **Phacops** sp., **Lingula** sp.

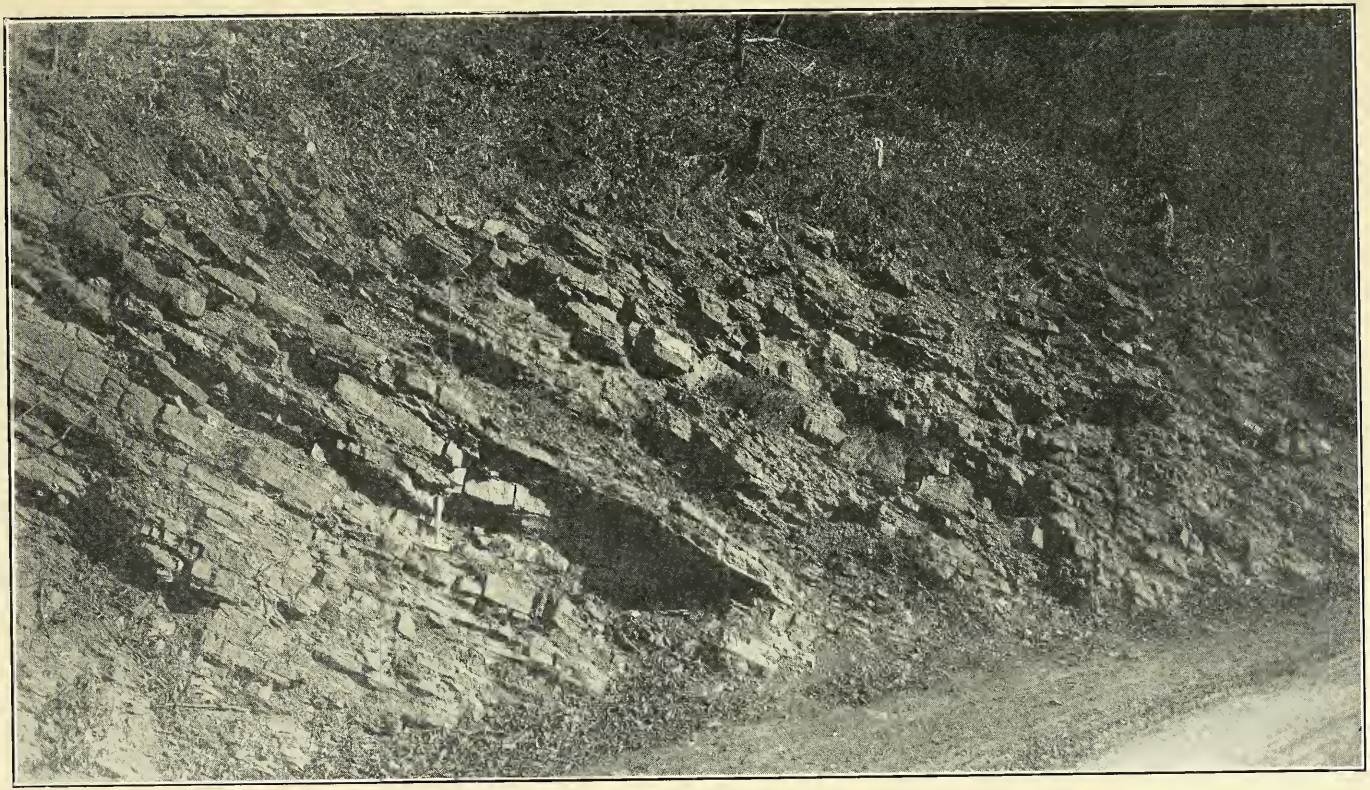


PLATE XXXII.—Typical view of calcareous portion of Martinsburg Series along highway on east side of New River, Giles County, Virginia, between Narrows and Rich Creek. Bedding is natural and dip southeast. See Rich Creek Section. (Photo. by Palmer & Fowler).

Lot 11 (Lower than Lot 10 and near base of series).—**Rafinesquina alternata** Emmons (a), **Dalmanella testudinaria** Dalman (a), **Rafinesquina fracta** Meek (c), **Zygospira modesta** (Say) Hall, **Pholidops cincinnatiensis** Hall (c), **Calymene** sp.

Fossil Lot 61 on Map IV was collected by Dr. Prouty and the writer in Monroe County along the Back Valley Anticline, in the road on Ewin Run of Potts Creek 0.1 mile northeast of Sugar Grove School and 1.6 miles south of Linton, possibly about the middle of the Martinsburg, its fauna being listed as follows by Dr. Prouty:

Isotelus cf. **gigas** DeKay (aaa), **Zygospira recurvirostris** Hall, **Rafinesquina** sp.

Fossil Lot 63 on Map IV was collected by Dr. Prouty and the writer farther west on the same anticline, on Trout Branch of Potts Creek 1.9 miles southeast of Laurel Branch, being in the **Lingula nicklesi Zone** at the top of the Lower Maysville Group. At this point Dr. Prouty reports **Lingula nicklesi** Bassler (aaa), etc., the remaining species not being detailed.

CORRELATION, MARTINSBURG SERIES.

The term Martinsburg which was originally used by Darton (Amer. Geol., Vol. X, p. 13) is regarded by most authors as largely synonymous with part of the Hudson River Shales or Slates of New York State, which were studied and described at a much earlier date and which would, of course, be entitled to preference, if the boundary and characteristics were in sufficient accord. Most authors in the middle Appalachian region in the last three decades, however, have adopted the Martinsburg as a more fitting designation for these beds while at the same time conceding their close affinity to the Hudson River. In the southern Appalachian States beds of much the same age have been extensively described as the Sevier Shale, this being followed below by the Tellico Sandstone and Athens Shale. It is not immediately apparent whether the Tellico Sandstone belongs within the rocks included under the Martinsburg but in any case this sandstone has no representative

in southern West Virginia, and hence the problem is not one of immediate concern. The relationships of the Athens Shale are likewise in doubt. It appears to be classed by some authors as in part the equivalent of the lower beds of the Sevier and by others it is partly indicated as of Chickamauga (Stones River) age. In other reports both the Tellico Sandstone and Athens Shale are put in independent positions between the Sevier and Chickamauga.

In Ohio the rocks of Martinsburg age have been generally included under the Cincinnati Series, but this series has also included the Richmond Group with which it has not yet been possible to correlate any portion of the Martinsburg Series of West Virginia. In Kentucky the Martinsburg has been generally described as the Cincinnatian or Hudson River Series but the classifications usually include the Richmond at the top and possibly some older beds at the base.

Some further remarks on the correlation of the subordinate groups of the Martinsburg will appear under the descriptions which follow.

DESCRIPTION OF GROUPS, MARTINSBURG SERIES.

LOWER MAYSVILLE GROUP, MARTINSBURG SERIES.

The term Maysville was first used by Foerste[1] in the description of beds which outcrop at Maysville, Kentucky, near Cincinnati, with the statement that the title was employed to supplant the name of Lorraine under which the beds had previously been classified, and with the explanation that they were contained in an essentially distinct zoological province.

At Cincinnati the Maysville Group was later studied in detail by Fenneman[2] and was divided into two formations with the retention of the minor subdivisions of Foerste, the descending succession being as follows

[1]Aug. F. Foerste, Science, N. S., Vol. XXII, pp. 149-152; 1905.

[2]N. M. Fenneman, Geology of Cincinnati and Vicinity, Geol. Survey of Ohio, 4th Ser., Bull. 19, p. 59; 1916.

Formation.	Member.	Thickness in Feet.	Character.
McMillan Formation	Mt. Auburn concretionary shale	20 to 35	Blue shale with irregular or concretionary beds of limestone.
	Corryville shale	35 to 50	Shale with thin beds of limestone.
	Bellevue limestone	0 to 23	Very fossiliferous limestone.
Fairview Formation	Fairmount limestone	70 to 85	Predominantly limestone with subordinate shale.
	Mt. Hope shale	16 to 50	Predominantly shale, but containing many beds of limestone.

In West Virginia, as previously discussed by the writer[3], Dr. Tilton and Dr. Prouty have identified the upper portion of the Martinsburg Series with the lower portion of the Maysville Group and it is probable that these rocks correspond in large part to the Fairview Formation, although the lithology is quite different and there are also faunal distinctions. No representative of the upper part of the Maysville has yet been reported in West Virginia and it may therefore be inferred that the McMillan Formation is largely absent. It does not appear safe, however, to correlate the West Virginia Maysville with the Fairview Formation in its entirety, hence the term Lower Maysville has been used in the Mineral and Grant Report and in the present Report as the most convenient term for these rocks. The Lower Maysville Group, as above defined, consists mostly of brown, friable sandstone and brown shale, with a few lenses of limestone in the lower part, and with abundant marine fossils from top to bottom. By way of faunal distinction its extreme upper part was designated in the Mineral and Grant Report of the writer as the **Lingula nicklesi Zone** because of the great abundance of this fossil, and the beds next beneath were called the **Orthorhynchula linneyi Zone.** The two fossils named are not exclusively confined

[3]David B. Reger, Mineral and Grant Report, W. Va. Geol. Survey, pp. 428-429; 1924.

to their respective zones but in both cases the occurrences are so abundant that there is little difficulty in recognizing the two zones even in southern West Virginia nearly 200 miles from the original point of designation. In Mercer and Monroe Counties the Lingula Zone is about 50 feet thick and the Orthorhynchula Zone is 150 to 200 feet thick. Just beneath the latter zone and at the base of the Lower Maysville there is another zone of shaly and partly calcareous rocks to which no definite name has been assigned.

The Lower Maysville Group outcrops for more than 60 miles along the northern slopes of East River Mountain and Peters Mountain, occurring just beneath the red sandstone and shales of the Red Medina Series and being easily recognized both by the brown color and the friable character of the rocks and by the abundant marine fossils which may always be found. The basal contact with the Eden Group is not so distinct, being based partly on the prevailing brown color of the shales of the Maysville as compared to yellow in the Eden and partly on fossil evidence, the common Maysville forms of **Lingula nicklesi, Orthorhychula linneyi,** and **Modiolopsis modiolaris** being apparently absent in the Eden. The group may be studied to best advantage in the edge of Giles County in the public road on the east side of the narrows of New River, where, as indicated in the Rich Creek Section, pages 210-11, it is 362 feet thick. **Fossil Lots 22, 23, and 24 on Map II** were collected from it by Dr. Prouty and the writer, the detailed lists of which by the former appear in the Rich Creek Section. In Monroe County the presence of this group is again noted in the Hanging Rock Section, page 234, but it was not given sufficient study to differentiate it from the Eden although this would appear quite possible. **Fossil Lot 71 on Map IV** was collected by Dr. Prouty and the writer, the identifications of which by Dr. Prouty appear in the Hanging Rock Section. In Potts Valley the Lower Maysville Group is again exposed along the Back Valley Anticline where **Fossil Lot 63 on Map IV** was collected by Dr. Prouty and the writer from the Lingula Zone as previously noted on page 609.

EDEN GROUP, MARTINSBURG SERIES.

The Eden Group, which was first so described by Orton[4] from exposures at Eden Park, a suburb of Cincinnati, Ohio, comprises the middle portion of the Martinsburg Series of the southern counties according to the paleontologic determinations of Dr. Prouty. This subdivision is correlated by most authors with the Utica Shales of New York, with which it appears largely to correspond, although the boundaries may not be quite the same. It is partly composed of yellow, sandy or calcareous shale, which weathers into small triangular or rhombohedral blocks, and partly of blue, flaggy, crystalline limestone, the positions of shale and limestone varying greatly at different localities, there being usually an interbedding of the two. Marine fossils occur in great abundance throughout the group. The upper contact with the Lower Maysville Group has already been discussed under the description of the latter. The base of the Eden rests upon the Trenton Group without much perceptible difference in lithology but with a very considerable break in the fossil content, the statement being made by Fenneman (Geol. of Cincinnati and Vicinity, page 61) that 90 per cent. of the species in the highest beds of the Cynthiana (a local phase of the Trenton) fail to reappear in the Eden.

The outcrop of the Eden occurs on the northern slopes of East River Mountain and Peters Mountain entirely across Mercer and Monroe Counties, and it is also found along the Back Valley Anticline in Potts Valley of Monroe County. It may be studied to best advantage, however, in the edge of Giles County on the east side of the narrows of New River, where it is quite well exposed, with a thickness of 455 feet, as indicated in the Rich Creek Section, pages 210-11. At this exposure **Fossil Lots 25, 26, 27, 28, and 29 on Map II** were collected by Dr. Prouty and the writer, as specified in detail by the former in the Rich Creek Section. In Monroe County it is noted in the Hanging Rock Section, pages 234-5, but is not

[4]Edward Orton, Geology of Cincinnati Group, Geol. Survey of Ohio, Vol. I, Pt. 1, pp. 370-373; 1873.

therein differentiated from the overlying Lower Maysville, the combined thickness of the two groups being 1023 feet. **Fossil Lot 98 on Map IV** was collected by Dr. Prouty and the writer from the lower 18 feet of the Eden Group at this locality, the fauna being listed by Dr. Prouty in the Hanging Rock Section.

TRENTON GROUP, MARTINSBURG SERIES.

The Trenton Group, or Trenton Limestone, of Vanuxem[5] comprises the lower portion of the Martinsburg Series of the local area. This formation has been studied and discussed by so many authors through the Appalachian region that no review of its correlation appears required in the present Report. Its local phase is that of a blue, flaggy, and highly crystalline limestone interlaminated with thin beds of gray calcareous shale and containing abundant marine fossils throughout its mass. Most of the limestone flags are quite pure but the intermediate shales greatly reduce the general content of lime. The upper boundary of the Trenton has already been discussed with the statement that it can be recognized only by fossil study. Its base rests upon the red earthy and non-fossiliferous Moccasin Limestone, the difference between the two being readily apparent at all points. At this horizon there is also a streak of black, fissile, carbonaceous shale, and the presence of this same shale has been noted at many other localities in the Appalachian region, indicating that the basal beds of the local Trenton are probably all represented.

The Trenton outcrop extends along the northern slopes of East River Mountain and Peters Mountain and is apparently included in the exposure of Martinsburg along the Back Valley Anticline in the Potts Valley region of southern Monroe, although no collections were made to determine this point. In the edge of Giles County, Virginia, it is well exposed on the east side of the narrows of New River as recorded

[5]Lardner Vanuxem, New York Geological Survey, 4th Ann. Report, pp. 364-367, 371; 1840.

in the Rich Creek Section, page 211, where it is 731 feet thick and is almost completely exposed along the highway. **Fossil Lots 30, 31, and 32 on Map II** were collected by Dr. Prouty and the writer, the lists of which as determined by the former appear in the Rich Creek Section. These, however, do not include any collections from the lower 176 feet of the formation.

Another very good exposure is afforded on the northern slope of Peters Mountain three or four miles southwest of Gap Mills, as noted in the Hanging Rock Section, pages 235-7, where it is 322 feet thick. **Fossil Lots 72-79,** inclusive, **on Map IV** were collected by Dr. Prouty and the writer as detailed by the former in the Hanging Rock Section. These 26 collections include a study of almost every foot of the formation.

ECONOMIC ASPECTS, MARTINSBURG SERIES.

The Martinsburg Series in the local area appears to be of principal value in the formation of agricultural soils, particularly in the Eden and Trenton Groups where limestone and calcareous shales are abundant. It is not readily apparent whether any commercial use could be made of these limestones, although the flags are often quite pure. For general quarrying purposes they would probably be objectionable because of the included shales. It might be possible, however, that a chemical study would reveal localities where the combined limestone and shale might have a composition that would not be unfavorable for the manufacture of Portland cement, but such a study was not made on account of the vast amount of pure limestone which occurs in the Stones River outcropping at the base of the mountains where the Eden and Trenton are found. It is, of course, true that the Trenton has produced great quantities of oil and gas in Ohio and Indiana and elsewhere but it is extremely doubtful whether these would be found in Mercer and Monroe Counties, and the beds are so deeply buried at all points north of the St. Clair Fault that their exploration would not be looked upon with favor in view of the lack of any evi-

dence that they contain oil or gas in adjoining regions. In the broken and faulted region of southern Mercer and southern Monroe no such deposits need be anticipated.

MOCCASIN LIMESTONE.

GENERAL ACCOUNT, MOCCASIN LIMESTONE.

The Moccasin Limestone, first described by Campbell[6] in Scott County, Virginia, is a red, argillaceous, earthy, and non-marine deposit, the position of which in the local area is just below the Martinsburg Series and just above the Stones River (Chickamauga) Limestone. As a rule this limestone is medium-hard and has poorly defined bedding-planes, its fracture being irregular and rough. The color is often mottled, some parts of a boulder exhibiting a pale red color and others showing a dirty gray, as though there may have been invasions of inconstant currents of muddy water when deposition was in progress.

Its thickness appears to vary from 400 to 450 feet, the former figure being more nearly the average. In the narrows of New River a measurement by Price and the writer along the Virginian Railway grade, as recorded in the Rich Creek Section, page 211, shows a thickness of 419 feet. In Monroe County on Peters Mountain three or four miles southwest of Gap Mills it measures 396 feet, as noted in the Hanging Rock Section, page 237, and farther east along the same mountain, as will be later detailed under the subject of "Subdivisions", a thickness of 350 feet was found.

SUBDIVISIONS, MOCCASIN LIMESTONE.

The Moccasin Limestone has never been divided into members, there being neither fossil zones nor apparently constant lithologic differences. In most of the local area this is the case but on the northern slope of Peters Mountain, Monroe County, two miles southeast of Gap Mills and just east of a

[6]M. R. Campbell, Estillville Folio, No. 12, U. S. Geol. Survey; 1894.

road which ascends the mountain, some more pronounced lithologic differences and evidences of bedding occur. Here the following notes were obtained by Dr. Prouty and the writer, the arrangement being in descending stratigraphic order and the thicknesses being largely estimated:

	Thickness. Feet.	Total. Feet.
Martinsburg Series (....)		
1. Limestone, blue, flaggy, with marine fossils; bryozoa, crinoids, brachiopods, etc.; not measured.....	....	....
Moccasin Limestone (350')		
2. Limestone, red and yellow.....	50	50
3. Sandstone, yellow, with prismatic weathering and with streaks of limestone, exposed along flat ridge.....	75	125
4. Limestone, yellow, shaly.....	35	160
5. Sandstone, yellow, flaggy.....	45	205
6. Limestone, red, shaly.....	60	265
7. Limestone, gray, flaggy; contains some weathered out and indistinguishable marine fossil forms.....	45	310
8. Limestone, red, earthy (2570' B.)....	40	350
Stones River (Chickamauga) Limestone (....)		
9. Limestone, gray, pure; not measured	....	....

The above section is quite different from the usual occurrence of the Moccasin Limestone, both on account of the two beds of sandstone and because of the fossil fragments which are noted in No. 7. In view of the absence of any marine zones elsewhere in the Moccasin and on account of the weathered condition of the species, it appears probable that they may belong in drifted material which became imbedded in the calcareous muds of the Moccasin sea. It is not apparent that this single exposure of somewhat well-defined bedding affords enough evidence for subdividing the Moccasin and hence it is not attempted in this Report.

TOPOGRAPHIC EXPRESSION, MOCCASIN LIMESTONE.

The Moccasin Limestone in the local area occurs principally along the sides of mountains where it sometimes forms some slight shoulders which stand out beyond the smooth slope formed by the Martinsburg Series above it, and con-

trasts with the sink-holes of the Stones River Limestone farther down. These are only occasional protuberances, however, no continuous ledges or benches being made.

AREAL EXTENT, MOCCASIN LIMESTONE.

In Mercer County the Moccasin Limestone outcrops along the northern slope of East River Mountain, starting at the Tazewell County line south of Bluefield and extending northeastward to the Giles County line south of Glenlyn. In the edge of Giles County it crosses the narrows of New River about 1½ miles south of Rich Creek Station and continues into the northern slope of Peters Mountain. Entering Monroe County slightly less than two miles southeast of Peterstown it follows along the slope of Peters Mountain to the line of Alleghany County, Virginia, east of Sweet Springs. The length of the outcrop across these three counties is approximately 62 miles but its width is seldom in excess of one-fourth or one-third mile.

Another exposure of the Moccasin occurs along the Back Valley Anticline in the Potts Valley region of Monroe County partly on the southern limb of the fold and partly on the northern limb, the latter area being largely eliminated by the Sugar Grove Fault, as exhibited on Map IV.

CONTACTS, MOCCASIN LIMESTONE.

The upper boundary of the Moccasin has already been discussed under the description of the overlying Martinsburg Series, there being evidence of unconformity and diastrophism. Its base rests upon the pure and fossiliferous Stones River (Chickamauga) Limestone, following the deposition of which it is evident that the diastrophic action that elevated the bed of the Moccasin sea must have originated. The extent of the unconformity at this stage can scarcely be estimated because of the barren character of the Moccasin, but if it mainly represents a non-marine phase of the Chambersburg Limestone, as Dr. Prouty has tentatively suggested, it may be possible that no extensive time break occurred, although it is difficult

to compare these rock beds with the Ordovician column in more northeastern States where there is a succession of marine faunas.

FOSSIL LIFE, MOCCASIN LIMESTONE.

It has already been stated that the Moccasin Limestone contains no marine fossils so far as observed or so far as elsewhere recorded. This statement must be modified, however, by the local occurrence of worn out and indistinguishable species at one locality in southeastern Monroe County, as previously indicated on page 617. These probably occur in fragments of older limestone carried into the Moccasin sea.

CORRELATION, MOCCASIN LIMESTONE.

Dr. Prouty has stated (in a letter) that the Moccasin is probably of Upper Chambersburg age, and if this be true it must belong in the upper part of the Black River division of the general time scale. In the southern Appalachian States it has generally been designated by the name Moccasin or by some other local title but in the Newman Trough of the Tennessee Basin the presence of the Black River Group has been indicated. It would appear that the relationships of the Moccasin with the Chambersburg and other formations in States farther northeast will be more fully revealed after it has been traced northeastward across West Virginia and Virginia into the Potomac region of Maryland.

ECONOMIC ASPECTS, MOCCASIN LIMESTONE.

The Moccasin Limestone weathers into a fairly rich soil which can not be easily cultivated, however, on account of the occasional reefs of stone which still protrude, its principal value being for grazing purposes. The limestone is generally too impure to be used for any purpose where high-grade material is necessary, and it has no qualities of texture or cleavage that would make it desirable for building stone. A sample for chemical analysis was collected on Pigeon Creek, Mercer

County, the composition of which will be found in the Table of Limestone Analyses at the end of Chapter XIV.

STONES RIVER (CHICKAMAUGA) LIMESTONE.

GENERAL ACCOUNT, STONES RIVER (CHICKAMAUGA) LIMESTONE.

The Stones River (Chickamauga) Limestone, occupying a position just below the Moccasin and just above the Beekmantown, is a massive deposit of almost pure calcium carbonate, varying in thickness from 500 to 700 feet. Its upper and middle portions are gray or dove-colored, crystalline, hard and very pure but the lower third is usually quite dark, somewhat granular, and impregnated with numerous irregular nodules of black chert, and occasionally exhibiting a wavy, banded structure. On account of its high lime content the entire formation weathers readily into large sinks, and as is the case with most pure limestones, its occasional columnar remnants are resilient and give a musical, or bell-like sound when struck by the hammer, in marked contrast to the dull thud of a dolomite or siliceous or earthy lime. At some points it shows a considerable degree of metamorphism, its structure approaching that of a marble but lacking the definitely crystalline structure and lustre of the Holston Marble of Virginia and Tennessee which occurs in the same formation. Such instances are usually in the lower part and correspond in color to the dark matrix but are infrequent. As a rule, however, the original marine content of the formation is still evident on close inspection and at occasional localities some of the fossils are still in a fair state of preservation.

In South Bluefield, Mercer County, the thickness of the Stones River was roughly measured by Dr. Prouty and the writer as 500 feet. In the narrows of New River it is recorded as 487 feet in the Lurich Section, page 205, and as 618 feet in the Rich Creek Section, page 211. In Monroe County it was measured as 690 feet in the Hanging Rock Section, page 237, while in Potts Valley it shows a thickness of about 400 feet near Sugar Grove School, its full section not being exposed.

SUBDIVISIONS, STONES RIVER (CHICKAMAUGA) LIMESTONE.

In the eastern Panhandle of West Virginia Grimsley[1] divided the formation into the **Upper Stones River Limestone, Middle Stones River Limestone,** and **Lower Stones River Limestone,** this classification being in line with the previously published composite section of Stose (Jour. Geol., Vol. XVI, p. 708, and Mercersburg-Chambersburg Folio, No. 170) which Grimsley quotes as follows:

	Feet.	
Thin-bedded, fine-grained, pure dove-colored limestone	275±	
Massive, pure limestone with **Maclurea magna** and black chert layers. Upper part compact, blue to dark; lower part, light-gray, granular and oolitic, 150′ to	200	
Massive and thin-bedded limestone interbedded with magnesian layers	600±	1050±

The context of Dr. Grimsley's Report shows that his subdivisions are based on the tripartite description of Stose where no actual titles were employed. If the names used by Grimsley be combined with the descriptions of Stose a very logical and valuable classification is obtained.

In the type locality of the Stones River in Tennessee the following appears to be the present accepted descending succession of the group, as partly defined by Safford and as many years later redefined by Ulrich and Hayes as cited on a following page:

	Feet.	
Carters Limestone, heavy-bedded, fine-grained, white, or light-blue limestone, often containing chert and silicified fossils	40 —	60
Lebanon Limestone, thin-bedded, often shaly, fine-grained, bluish or dove-colored limestone, frequently weathering yellow	70 —	100
Ridley Limestone, massive, subgranular, often cherty		80
Pierce Limestone, shaly, crowded with bryozoans		27
Murfreesboro Limestone, heavy-bedded, cherty (base not exposed)		125

[1]G. P. Grimsley, Jefferson, Berkeley, and Morgan Report, W. Va. Geol. Survey, pp. 265-271; 1916.

In the above list the descriptions and thicknesses of the lower three members are quoted from R. S. Bassler (Cambrian and Ordovician Deposits of Maryland, p. 118; 1919) who does not mention the Carters Limestone as a member of the formation. Bassler also adds the very interesting statement that the upper third (Upper Stones River) of northern Virginia, Maryland, and Pennsylvania corresponds to the Lebanon, the middle third (Middle Stones River) to the Ridley and Pierce, and the lower third (Lower Stones River) to the Murfreesboro.

In Mercer and Monroe Counties it is apparent that the beds represent the Upper Stones River (Lebanon) and Middle Stones River (Ridley and Pierce), there being no vestige of the Lower Stones River which is evidently a northeastern development, since no member of its character is mentioned in the southern States where the Stones River has been described under the name of Chickamauga Limestone in many folios.

TOPOGRAPHIC EXPRESSION, STONES RIVER (CHICKAMAUGA) LIMESTONE.

On account of its soluble character the Stones River Limestone almost invariably occupies low ground as compared to the adjacent rocks. In Mercer and Monroe its principal outcrop is along the northern bases of East River Mountain and Peters Mountain where it often forms a distinct valley flanked on the south by the impure Moccasin Limestone and on the north by the hard and dolomitic Beekmantown Limestone. In addition to the generally low topography its outcrop is further featured by many sink-holes, some of which are more than a mile in length and more than 100 feet deep. These sinks form a ready means of finding its outcrop since no other local Ordovician formation makes them. Owing to the numerous sinks and generally irregular weathering the ground contour is often quite rough.

AREAL EXTENT, STONES RIVER (CHICKAMAUGA) LIMESTONE.

In Mercer County, as indicated on Map II, there is a brief wedge of Stones River in the valley of Beaver Creek in

South Bluefield next to the Tazewell County line, occurring between two limbs of the St. Clair Fault, being about 1½ miles long and less than one-half mile wide. South of the St. Clair Fault in the same county a more extensive belt starts at the Tazewell County line and follows northeastward across the county, its position being generally in the low topographic shelf, or depression, at the northern base of East River Mountain except in the region south and southeast of Wills Station where there is no depression and where it therefore forms part of the lower slope of the mountain.

In the edge of Giles County, Virginia, it crosses the narrows of New River about 1½ miles south of Rich Creek Station, being poorly exposed on the west side but very well displayed in the cut of the Virginian Railway on the east side.

In Monroe County it forms a narrow belt along the lower northern slope of Peters Mountain southeast of Peterstown, and continuing northeastward along this mountain it makes a generally, though not always, depressed topography with numerous sink-holes until it finally swings slightly northward in the vicinity of Sweet Springs and there occupies the valley of Sweet Springs Creek and some of the low topography to the northward. Just beyond Sweet Springs it enters Alleghany County, Virginia. On Turkey Creek one mile east of McGlone a brief wedge of Stones River occurs just north of the St. Clair Fault, being about 1½ miles long and less than one-fourth mile wide. In Potts Valley it occupies the crest of the Back Valley Anticline for two miles next to the line of Craig County, Virginia, and thence extends northeastward into the latter county.

At the northern bases of East River Mountain and Peters Mountain the formation may be studied to good advantage at many points, as well as in the narrows of New River. In the three other small outcrops mentioned it is faulted and its relationships are less easily discerned.

CONTACTS, STONES RIVER (CHICKAMAUGA) LIMESTONE.

The upper contact of the Stones River with the Moccasin Limestone has already been discussed under the description

of the latter on previous pages, where a diastrophic movement of some consequence has been postulated. Concerning this movement Hayes and Ulrich[8] say:

> "The wide and even distribution of the Stones River Group, which includes the Carters and Lebanon Limestones, as shown in the Correlation Table, and the erosion unconformity at its top, clearly indicate that the Cincinnati Geanticline was elevated above sea level, probably for the first time, at the close of the Stones River epoch."

At its base the Stones River rests upon the Beekmantown Limestone where there appears to be a considerable unconformity. As already stated the Lower Stones River (Murfreesboro) is absent and this is the case also with the Mosheim and Frederick Limestones. Farther down Ulrich[9] interposes an "Unnamed Epoch", comprising the Joachim, St. Peter, and Everton Formations, all of which are western types. It thus seems apparent that a very considerable break in sedimentation occurred between the top of the Beekmantown and the base of the Middle Stones River which rests upon it in the local area.

In Mercer and Monroe Counties this lower contact is generally marked by the presence of black chert in the Stones River and by gray, granular, scoriaceous, or blocky chert in the Beekmantown, as well as by a marked difference in the matrix, the Beekmantown being a gray, inert dolomite while the Middle Stones River is a dark, effervescent limestone, and also by a faunal difference, there being occasional Beekmantown fossils in the dolomite and a somewhat more constant fauna in the Stones River.

FOSSIL LIFE, STONES RIVER (CHICKAMAUGA) LIMESTONE.

In the Stones River there is usually a considerable marine fauna both in the upper dove-colored portion and in the lower dark and cherty limestone, but in many instances the species are partly obliterated by the lateral compression in the rocks

[8] C. Willard Hayes and E. O. Ulrich, Columbia Folio, No. 95, U. S. Geol. Survey; 1903.

[9] E. O. Ulrich, Revision of the Paleozoic Systems, Bull. 22, Geol. Soc. Am., Pl. 27 (1909); 1911.

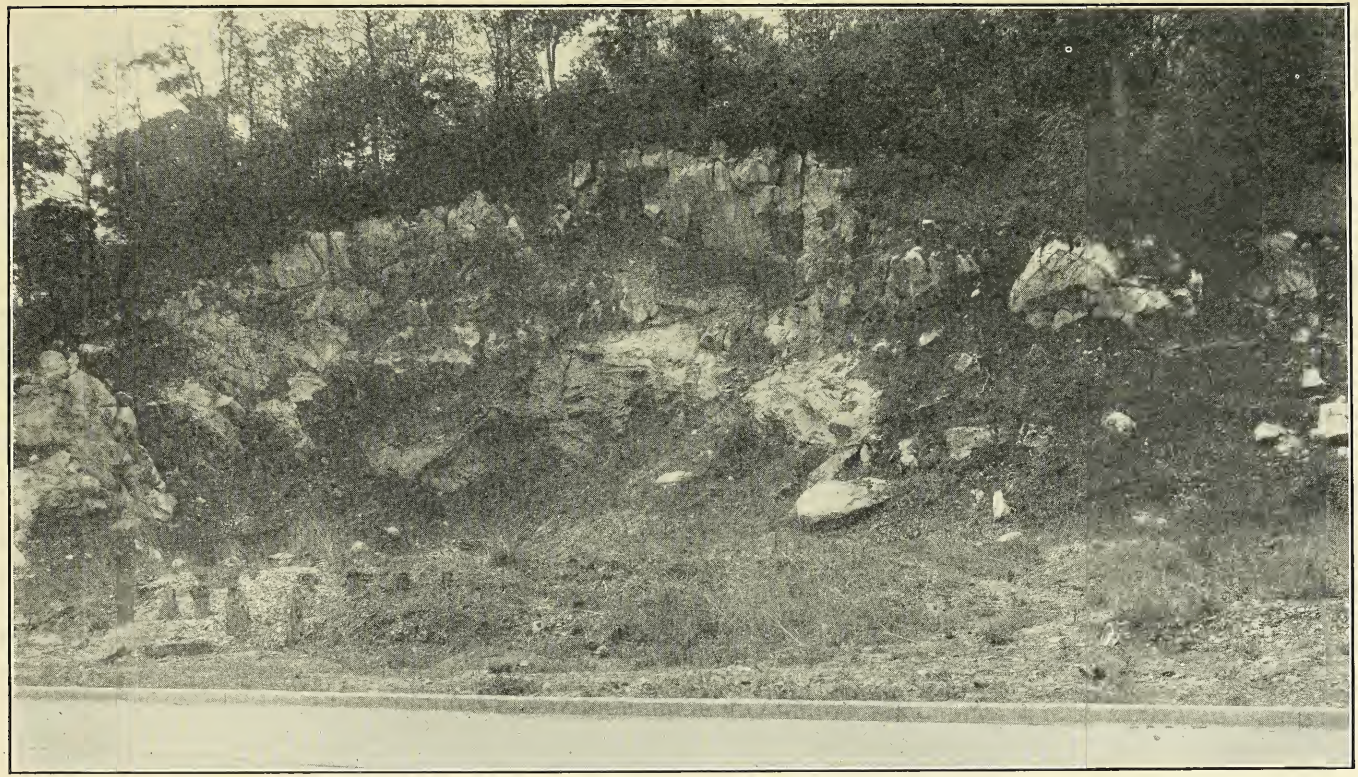


PLATE XXXIII.—View of Stones River (Chickamauga) Limestone at R. F. Baker quarry in South Bluefield near Country Club. Exposure occurs in wedge between two limbs of St. Clair Fault and is much broken. (Photo. by Palmer & Fowler).

and even when not so affected they are generally hard to recover from the massive limestone. **Fossil Lot 12 on Map II** was collected by Dr. Prouty and the writer at the R. F. Baker quarry in South Bluefield, Mercer County, and according to Dr. Prouty contained many poorly preserved gastropods, **Omospira** cf. **alexandra?** Billings.

In South Bluefield the following local measurement was obtained:

Local Measurement at Fossil Lots 47 and 48.

Beaver Pond District, Mercer County; at foot of East River Mountain, 0.6 mile northeast of Bailey School and 1.6 miles southeast of Bluefield Station; limestone quarry of S. J. Sublette; rapid southeast dip; arrangement in descending stratigraphic order.

	Thickness. Feet.	Total. Feet.
Stones River (Chickamauga) Limestone (105′)		
1. Limestone, gray, compact, fine-grained, quarry rock, with marine fossils (2745′ B.). **Lot 48**; contains **Lophospira perangulata** Hall, **Liospira** cf. **vitruvia** Billings, **Maclurea** cf. **bigsbyi** Hall...	75	75
2. Limestone, dark, granular, with black chert and marine fossils. **Lot 47**; contains **Leperditia** cf. **fabulites** Conrad var., **Rafinesquina** sp., many fragments of trilobites; visible thickness.....	30	105

At the above locality **Fossil Lots 47 and 48 on Map II** were collected by Dr. Prouty and the writer as above specified by the former. There is little doubt that Lot 47 is in the Middle Stones River and it is probable that Lot 48 is in the Upper Stones River judging from its lithologic difference. On the head of Pigeon Creek just west of the residence of Floyd Dickson 2.1 miles south of Oakvale **Fossil Lot 44 on Map II** was collected by Dr. Prouty in dove-colored limestone coming just below the red Moccasin Limestone, the collection being described as poorly preserved material with **Zygospira** sp., bryozoa sp., **Orthoceras** sp. and small, smooth ostracods, with the comment that it is probably the top of the Stones River or Chambersburg. **Fossil Lot 45 on Map II** was collected by Dr. Prouty slightly north of Lot 44 and at a lower elevation and is reported as containing **Rafinesquina** sp., cf. **Christiana trentonensis Ruedemann,** and trilobite fragments,

with the comment that it is probably Chambersburg. **Fossil Lot 46 on Map II** was collected by Dr. Prouty and the writer about one-fourth mile north of Lot 45, and according to the former contained **Rafinesquina?** sp., and **Bumastus** sp. Dr. Prouty assigns this collection to the bottom of the Chambersburg Limestone. The presence of these Chambersburg fossils in beds which may be traced continuously along the base of East River Mountain and which elsewhere contain an undoubted Stones River fauna is difficult of explanation unless the range of the fossils is greater than has previously been supposed. In the edge of Giles County **Fossil Lots 19, 20, and 21 on Map II** were collected by Dr. Prouty and the writer from the poorly exposed Stones River beds on the west side of the narrows of New River, the fauna being indicated by Dr. Prouty in the Lurich Section, page 205. **Fossil Lot 60** was obtained by Dr. Prouty from some fragments of stone coming from the quarry of the Kimballton Lime Company at Kimballton, Giles County, Virginia, on the south side of Stony Creek about two miles from the Monroe County line, the fauna being reported as **Bumastus** sp. (aa), and assigned to the Chambersburg. Neither Dr. Prouty nor the writer visited this quarry but the Beekmantown outcrops along the railroad north of the creek and the quarry was naturally considered as belonging in the Stones River and that is probably the case in spite of this Chambersburg specimen.

Fossil Lot 53 on Map IV was collected by Dr. Prouty and the writer on the lower northern slope of Peters Mountain 1.2 miles southwest of Green Valley School and 3.1 miles southeast of Peterstown in gray limestone coming just below the red beds of the Moccasin. According to Dr. Prouty the fauna consists of **Bumastus** sp., **Nidulites** cf. **pyriformis** Bassler, and **Rafinesquina** sp., and he assigns it to the Chambersburg. This also belongs in the limestone that is herein mapped as the Stones River.

Fossil Lot 55 on Map IV was collected slightly north of Lot 55 and in beds that are 400 to 500 feet older and apparently near the contact with the Beekmantown, the fauna being described by Dr. Prouty as **Raphistoma** cf. **stamineum** Hall

(aaa), **Strophostylus?** sp. (a), and **Bythocypris** close to **cylindrica** Hall, with the comment that it is Chazyan, which is, of course, largely equivalent to Stones River.

Fossil Lot 58 on Map IV was collected by Dr. Prouty and the writer on a branch of Sweet Springs Creek 0.3 mile northwest of Sweet Springs, in the upper half of the Stones River, and in this collection Dr. Prouty identified **Solenopora compacta** Billings (a) and notes that it is probably Upper Chazyan.

Fossil Lot 70 on Map IV was collected in the road ascending Peters Mountain 3.3 miles southwest of Gap Mills, across the outcrop of the Stones River (Chickamauga) Limestone, its fauna being identified by Dr. Prouty in the Hanging Rock Section, page 237.

Fossil Lot 62 on Map IV was collected by Dr. Prouty and the writer in Potts Valley on Ewin Run of Potts Creek at Sugar Grove School 1.7 miles south of Linton and just south of the Sugar Grove Fault, the dip of the Stones River strata at that point being northward at an angle of 58 degrees, so that about 400 feet of the older limestone of this formation is visible southward toward the Back Valley Anticline. According to Dr. Prouty this collection contained many small gastropods like **Hormotoma, Zygospira** sp. (very small), large ramose bryozoa, **Orthoceras** sp.; and to this list he adds the comment that it is probably near the top of the Chambersburg. There appears to be little doubt, however, that this is the same limestone as the extensive belt of Stones River north of Peters Mountain.

CORRELATION, STONES RIVER (CHICKAMAUGA) LIMESTONE.

The Stones River Limstone was first described by Safford[10] from exposures near Murfreesboro, Rutherford County, Tennessee, being eventually defined by him as a group with several subdivisions, but through some unfortunate mischance it was considered to be of Trenton age. This early error in correlation appears to have caused later authors to disregard the title and in 1894 Hayes[11] described these beds as the

[10] J. M. Safford, Am. Jour. Sci., 2nd ser. Vol. XII, p. 254; 1851.
[11] C. W. Hayes, Chattanooga Folio, No. 6, U. S. Geol. Survey; 1894.

Chickamauga Limestone from exposures on Chickamauga Creek in Hamilton County, Tennessee, near Chattanooga, and under this title it was generally classified for many years in most of the folios and reports on the southern Appalachian States. In 1897, however, Winchell and Ulrich revived the title and in 1903 Ulrich and Hayes[12] studied it near the type locality and succinctly redefined its southern subdivisions. In 1909 Stose[13] recognized the group in eastern Pennsylvania and defined its position in relation to the other Ordovician beds of the northern Appalachian region and at the same time he and Ulrich correlated it with the Chazy of New York. In subsequent years the title has been adopted by the Surveys of West Virginia and Maryland.

In 1896 this limestone was mapped and described as the Chickamauga by Campbell in the Pocahontas Folio, No. 26, which covers part of Mercer County, but its correlation with the Stones River was not therein recognized. In the present Report it is mapped and described as the Stones River in the belief that it essentially corresponds with the original Stones River of Tennessee and to the upper two-thirds of the Stones River beds of the Potomac region which have now been carefully described in several authoritative folios and reports including the Jefferson, Berkeley, and Morgan Report of the West Virginia Geological Survey by G. P. Grimsley (1916), and the Cambrian and Ordovician Volume of Maryland by R. S. Bassler (1919). The name Chickamauga has also been used in a parenthetic sense and this usage is satisfactory so far as to establish a correlation with the preceding work of Campbell in the Pocahontas Folio but it does not express the relationship with the Chickamauga as described in some other folios where the term was made much more inclusive and embraced some beds of younger age, as has been carefully indicated by Ulrich in his "Revision of the Paleozoic Systems."

In Mercer and Monroe Counties this limestone was

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[12]E. O. Ulrich and C. W. Hayes, Columbia Folio, No. 95, U. S. Geol. Survey; 1903.

[13]G. W. Stose, Mercersburg-Chambersburg Folio, No. 170, U. S. Geol. Survey; 1909.

studied in the field by Dr. Prouty and the writer and its many lithological and faunal affinities, with the Stones River were recognized. In transmitting his lists of fossils Dr. Prouty has indicated the Stones River or Chazyan age of several of these collections but in others has apparently assigned them to the Chambersburg, probably on the purely technical aspects of the species. There can scarcely be a doubt, however, that all the limestone coming between the Moccasin and Beekmantown in the local area is an unchanging group in the two counties, since the stratigraphic relationships can be followed for more than 60 miles along the northern fronts of East River Mountain and Peters Mountain, including the narrows of New River, there being no interruption in the sedimentation nor any further extensive concealment of the beds along this whole outcrop. That being the case the writer believes that the occasional presence of Chambersburg species may be entirely due to a greater range in these types than has been hitherto suspected or to provincial geological conditions, and does not imply the actual occurrence of the Chambersburg Limestone of Pennsylvania which does not appear to be present unless it is represented by the overlying Moccasin.

ECONOMIC ASPECTS, STONES RIVER (CHICKAMAUGA) LIMESTONE.

The weathered outcrop of the Stones River Limestone forms a dark red soil that is one of the most fertile belts in the whole Appalachian region, being so recognized for many hundreds of miles in the Great Valley as well as in the less continuous exposures in the Allegheny Ridges of which the local area is a part. Owing to the presence of many reefs or turrets of unweathered and protruding limestone there are large areas of the outcrop that can not easily be cultivated and hence it is best adapted for grazing. A feature of this soil, which has been noted by various authors, is its peculiar adaptation to the growth of cedar trees, which may be found along its outcrop in many of the Appalachian States, but which are not especially prominent in Mercer and Monroe Counties although occasionally noted.

The mineralogical aspects of the Stones River are of prime importance. Around Bluefield it has been quarried at several points for macadam and concrete aggregate and for both of these purposes it is quite successful, but it could not, of course, be used in strictly fire-proof buildings. A very considerable portion of the Upper Stones River Limestone, which is the upper half of the formation, as mapped in these counties, and is generally a dove-colored limestone quite free from chert, is especially pure, being very low in silica and other impurities and quite high in calcium carbonate, so that it can be used to good advantage for the manufacture of commercial lime or Portland cement or for blast-furnace fluxing as well as for many other chemical purposes. The description of numerous quarries and exposures together with chemical analyses will be found in Chapter XIV under the general subject of "Limestone."

BEEKMANTOWN LIMESTONE.

GENERAL ACCOUNT AND SECTION, BEEKMANTOWN LIMESTONE.

The Beekmantown Limestone, coming just below the Stones River (Chickamauga) Limestone and indicated on Maps II and IV as the oldest outcropping series in the local area, is chiefly a mass of dolomite or dolomitic limestone carrying abundant quantities of chert and having a scanty marine fauna which is generally visible only in weathered pieces of the chert. The strata definitely assigned to the Beekmantown vary from 2,000 to 2,500 feet in thickness, there being associated beds of apparently non-fossiliferous dolomite coming just below and being of probable Cambrian age although mapped with the Beekmantown for lack of proof.

The matrix of the Beekmantown proper is generally gray or slightly cream-colored but universally weathering to light-gray, there being some darker beds near the top. Its texture is often somewhat coarse but not noticeably crystalline and it is very hard, resounding with a dull, lifeless thud under the blow of a hammer in sharp contrast to the metallic ring of a

pure limestone. Bedding-planes are infrequent, there being occasional thin partings of gray or yellowish, calcareous shale.

The cherts appear to occur principally in the form of stratified layers at irregular intervals, being difficult to distinguish from the matrix on fresh surfaces but eventuallly weathering out into rectangular blocks and scoriaceous, cauliflower or roughly spheroidal forms in the middle and lower portions and generally into small, angular particles in the upper part. In this upper zone the color is partly black and partly gray but farther down black chert is seldom found, the prevailing color being gray. Many of the larger rectangular or spheriodal chunks exhibit a chalcedonic lustre on fresh fracture, especially those which enclose calcareous algae.

Beds of pure limestone are quite uncommon, being mostly confined to the upper portion and having a gray or dove color. Quartz pebbles are occasionally found and there are rare occurrences of reworked limestone or dolomite conglomerates, all such features being evidences of interrupted sedimentation.

At the eastern edge of South Bluefield a section roughly measured by Dr. Prouty and the writer across these ancient beds is as follows:

South Bluefield Section.

	Thickness. Feet.	Total. Feet.
Beekmantown Limestone proper (2460')		
1. **Chert, Narrows,** black, small angular fragments	283	283
2. Dolomite, dark	262	545
3. Dolomite, gray, cherty, with marine fossils; gastropods, **Ophileta complanata, Ophileta** cf. **levata,** and **Hormotoma** sp.	1915	2460
Beekmantown? or Elbrook? Limestone (1040')		
4. Dolomite, gray, hard, cherty, oolitic at top	1040	3500

In the Lurich Section, page 205, the visible thickness of Beekmantown on the west side of the narrows of New River just south of the St. Clair Fault is 950 feet. In the Narrows Section, pages 206-7, the Beekmantown proper is 2877 feet thick and the lower, or Elbrook? portion is 810 feet. In the Rich Creek Section, page 211, the amount of Beekmantown exposed on the east side of the narrows of New River just

south of the St. Clair Fault is 910 feet. In the Ripplemead Section, page 212, 670 feet of the upper beds of the Beekmantown are recorded; and in the Snidows Ferry Section, page 213, on the east side of New River and north of a syncline which crosses near Ripplemead, 590 feet of these upper beds are noted. In Monroe County the thickness of the Beekmantown proper, as recorded in the Hanging Rock Section, page 237, is 2400 feet, but the base of the formation is cut off or concealed by the St. Clair Fault, and the Elbrook? also is not exposed.

The following general section, compiled from the above sections and from numerous local exposures and fossil collections, indicates the nature of the Beekmantown proper, and associated older dolomite (Elbrook?) in Mercer and Monroe Counties and in the northern end of Giles County, Virginia, occupying the narrows of New River:

General Section of Beekmantown Limestone in Mercer and Monroe Counties, West Virginia.

		Thickness. Feet.	Total. Feet.
1.	**Chert, Narrows,** with dolomitic matrix which is often weathered out; chert is usually gray on top but black in lower portion; usually weathers into small irregular fragments but exhibits cauliflower weathering about 100 feet below top; zone of chert pebble conglomerate 50 feet below top; contains marine fossils, brachiopods (**Herbertella** sp.), gastropods (**Ophileta complanata, Maclurites** sp., and a long spired species), and bryozoa (generally ramose); also carries calcareous algae (**Cryptozoon steeli?**)	200 to 275	275
2.	Limestone, gray, with black chert....	40 to 50	325
3.	Dolomite, gray, cherty, with a little reworked conglomerate and infrequent quartz pebbles at base; occasional **Cryptozoon steeli?**.....	150 to 175	500
4.	Limestone, gray, dolomitic.....	40 to 50	550
5.	Dolomite, gray, with abundant gray chert which sometimes weathers into rectangular, chalcedonic blocks and sometimes into scoriaceous		

		Thickness. Feet.	Total. Feet.
	forms, with cauliflower zone near base; marine fossils in chert; gastropods (**Ophileta complanata, Raphistoma** sp.), and cephalopods (**Orthoceras** sp.); rather abundant **Cryptozoon steeli?** throughout....	350 to 400	950
6.	Dolomite, gray, cherty, with infrequent lenses of sandstone or oolitic material; some pure quartz and chalcedonic chert at base; marine fossils in chert, gastropods, (**Ophileta?**) and cephalopods (**Cyrtoceras** sp.); also **Cryptozoon steeli?**.....	300 to 350	1300
7.	Dolomite, gray, cherty; a few marine fossils in chert, gastropods (**Ophileta?**)	800 to 1000	2300
8.	Dolomite, gray, or yellowish-gray, with gray chert which weathers into rectangular blocks or scoriaceous forms; marine fossils in chert, gastropods (**Ophileta complanata, Ophileta** cf. **levata,** and **Hormotoma** sp.); also **Cryptozoon steeli?**.....	150 to 200	2500
9.	Dolomite—probably **Elbrook Limestone** of **Cambrian** age—gray or yellowish-buff, with bedded gray chert which weathers to rectangular blocks, and with thin, interbedded, yellowish-buff shales, and with occasional red inclusions along bedding-planes; no marine fossils or algae observed	700 to 1000	3500

In the above section an interrogation point is introduced after the names of fossils not referred to Dr. Prouty for determination. In the case of **Cryptozoon,** however, Dr. Prouty states (in a letter) that he recalls that **Cryptozoon steeli** is the most common form. In view of the possible existence of other species at some of the horizons he may not have inspected, this uncertainty is expressed by a question mark.

SUBDIVISIONS, BEEKMANTOWN LIMESTONE.

In the above general section eight zones of the Beekmantown proper have been indicated, their differences being based partly on color, chemical character, chert structure, and other lithologic peculiarities, and partly on faunal evidence. At most localities, however, the differences are so often obscure

and there are so many factors of possible significance still in doubt that it is considered advisable to employ a geographic name only in the case of the Narrows Chert member at the top of the formation. This bed, as will be later described in more detail, is apparently a constant and easily recognizable feature.

In the lower dolomite, which may belong to the Elbrook Limestone of Cambrian age, there is an alternation of thick-bedded dolomites and thin-bedded shales presenting no decided changes from top to bottom.

TOPOGRAPHIC EXPRESSION, BEEKMANTOWN LIMESTONE.

All exposures of Beekmantown in the local area consist of beds which dip southeastward at angles varying from 20 to 50 degrees and which quite generally occupy the foot-hill region at the northern bases of high mountains, there being important modifications immediately southward in Giles County, Virginia. At the bases of East River Mountain and Peters Mountain there is generally visible a noticeably depressed area at the top of the Beekmantown, this being made in part by the sink-holes of the overlying Stones River Limestone and in part by the weathered matrix of the Narrows Chert member of the Beekmantown. Such evidence naturally points to a calcareous base in this member, its unweathered character being seldom exhibited.

The middle portion of the Beekmantown usually makes a considerable ridge from which large masses of dolomite often protrude, there being other similar reefs of less magnitude made by the lower portions down the northern slopes of these ridges. Visible sink-holes seldom occur but under favorable topographic conditions the drainage finds a subterranean level through the medium of crevices or small cavities and eventually issues in the form of large springs. Plates XXVIII, XXIX, XXX, and XXXIV show various views of the Beekmantown.

AREAL EXTENT, BEEKMANTOWN LIMESTONE.

In Mercer County the Beekmantown and associated Elbrook (?) occupy the foot-hills at the northern base of East River Mountain and south of the St. Clair Fault which is nearly always the northern limit of these dolomites. This belt starts at the Tazewell County line south of Bluefield and passes northeastward through South Bluefield and on to the Giles County line south of Glenlyn. Crossing the narrows of New River a little more than one mile south of Rich Creek Station it enters Monroe County southeast of Peterstown, as shown on Map IV, and then forms buttresses at the northern base of Peters Mountain for many miles, but at the head of Turkey Creek east of McGlone the strip widens and its northern edge forms the southern slope of Gap Mountain and occupies the valleys of Back and Kitchen Creeks and the upper valley of Sweet Springs Creek. Slightly west of Sweet Springs the entire outcrop passes north of Sweet Springs Creek and soon enters Alleghany County, Virginia. The total length of the outcrop in Mercer and Monroe Counties, including the narrow, intervening neck of Giles County, is more than 60 miles but its width never exceeds 1½ miles and is often less than one-half mile.

CONTACTS, BEEKMANTOWN LIMESTONE.

The upper contact of the Beekmantown with the Stones River Limestone has already been discussed under the description of the latter formation, page 624, an unconformity of considerable consequence being indicated. The base of the local Beekmantown, as already discussed, is involved in doubt. If this contact properly belongs at the lowest zone in which marine fossils have been noted in the general section, that is to say at about 2500 feet below the top, and if the still lower dolomite is the Elbrook, both of which tentative conclusions have been reached by Dr. Prouty and are agreeable to the writer, it is evident that the Conococheague Limestone, with a reported thickness of about 1800 feet in the Potomac region of eastern West Virginia, Maryland, and Pennsylvania, is absent

from the local stratigraphic column. This limestone is described as the upper formation of the Cambrian along the Potomac hence its absence would argue in favor of an enlargement of the time break, or unconformity, that always occurs at the Cambrian-Ordovician contact. The contact of the Beekmantown proper with the underlying limestone herein doubtfully assigned to the Elbrook is marked by the presence of fossils in the Beekmantown as contrasted to their apparent absence in the Elbrook, and by the more massive character of the Beekmantown, the Elbrook being thinner bedded and having frequent interlaminations of shale. There is also a difference in color, the lower portion of the Beekmantown being gray as compared to frequent beds of yellowish-buff with tinges of red in the Elbrook.

FOSSIL LIFE, BEEKMANTOWN LIMESTONE.

The local marine invertebrate faunas of the Beekmantown, as observed by Dr. Prouty and the writer and as already indicated in the general section, pages 632-3, appear to be confined to four or five species of gastropods, two or three species of cephalopods, and one species of brachiopod. These fossils, without exception, were found only in weathered blocks of chert, there being no positive evidence that the dolomitic matrix contains them. In these cherts, moreover, the whorls of the gastropods blend so perfectly with the cavities of the container that they can usually be found only after a painstaking search, but in any case it is evident that the specimens are not abundant although the above summary of the species may be short of the actual truth.

Throughout the whole Beekmantown, apparently, the remains of calcareous algae are fairly numerous. These peculiar organisms, which are usually globular masses three or four inches in diameter, may be observed in cross-section by breaking open the usually spheroidal or occasionally blocky pieces of chert in which they have been preserved. In Maryland **Cryptozoon steeli** is the only species which has been

described by Bassler[14] as occurring in the Beekmantown and its presence is reported further as almost wholly confined to a particular zone near the middle of the formation. In Mercer and Monroe Counties, however, these algae occur throughout almost the entire mass of the Beekmantown so that they apparently have no value in the correlation of minor subdivisions. These forms were examined in the field by Dr. Prouty and the writer but no laboratory study of them was made, although Dr. Prouty states (in a letter) that **Cryptozoon steeli** is the most common form. A more intensive study will be necessary, however, to determine whether this is the only species.

Several collections of marine invertebrates were made in the Narrows Chert, as will later appear in the description of that member. In the remaining 2000 to 2200 feet of the Beekmantown proper, various collections were also made. **Fossil Lot 106 on Map II** was collected by Dr. Prouty and the writer in the hog lot of Robert Tuggle farm on Grassy Branch of East River 1.1 miles southeast of Bluefield Station, Mercer County, being only a short interval above the Elbrook? contact. According to Dr. Prouty this collection contained only **Ophileta complanata** Vanuxem. **Fossil Lot 107 on Map II** was collected by the same parties about 400 feet east of the Tuggle barn, slightly southeast of and slightly above Lot 106, the fauna, as reported by Dr. Prouty, being **Ophileta** cf. **levata** Vanuxem and **Hormotoma** sp. **Fossil Lot 109 on Map II** was collected by the writer in a road south of East River and 0.3 mile southeast of Wills Station, Mercer County, and just south of the St. Clair Fault which there cuts off the lower part of the Beekmantown, so that the horizon appears to be near the middle of the formation. This collection, according to Dr. Prouty, contains **Ophileta** cf. **complanata** Vanuxem and **Orthoceras** sp.

In Giles County, Virginia, **Fossil Lot 104** was collected by Dr. Prouty and the writer on a low spur of Wolf Creek Mountain lying on the west side of Mill Creek, south of Wolf

[14]R. S. Bassler, Cambrian and Ordovician Deposits of Maryland, Md. Geol. Survey, pp. 89-111; 1919.

Creek and about two miles southwest of Narrows. Here Dr. Prouty notes the presence of **Ophileta complanata** Vanuxem, the specimens being fairly numerous. As indicated in the Narrows Section, page 206, this zone is 816-906 feet below the top of the Beekmantown. **Fossil Lot 105** was collected farther down the same slope, as noted in the Narrows Section, page 207, but was only a loose boulder of chert which appears to have drifted to the locality, since it contains a younger fauna, as previously explained.

In Monroe County **Fossil Lot 139 on Map IV** was collected by the writer in the road at the head of Dropping Lick Creek 0.4 mile west of Zenith School and 1.5 miles east of Zenith village, being apparently 500 to 800 feet below the top of the Beekmantown. Dr. Prouty reports **Ophileta complanata** Vanuxem (aa) in this collection. **Fossil Lot 69 on Map IV** was collected by Dr. Prouty and the writer in a low ridge 1.3 miles northeast of Crimson Springs Church and 3.1 miles southwest of Gap Mills. This lot contained only a single specimen of **Maclurites** sp., as noted by Dr. Prouty in the Hanging Rock Section, page 234. **Fossil Lot 129 on Map IV** was collected by the writer along a hill road ascending from Turkey Creek up a spur of Gap Mountain 1.9 miles northeast of McGlone, being just south of the St. Clair Fault and approximately 2400 feet below the top of the Beekmantown proper, and therefore near the Elbrook? contact. As noted in the Hanging Rock Section Dr. Prouty reports only **Ophileta** sp. in this lot.

In the same county **Fossil Lot 132 on Map IV** was collected by the writer in the Gap Mills-Waiteville road 2.1 miles southwest of Gap Mills, being estimated as 1000 feet below the top of the Beekmantown, and according to Dr. Prouty contained **Cyrtoceras** sp. Just southwestward and probably 900 feet below the top of the formation **Fossil Lot 134 on Map IV** was collected by the writer, nothing except **Ophileta** sp. being noted by Dr. Prouty. Slightly farther southwest, and perhaps 700 feet below the top **Fossil Lot 133 on Map IV** was collected by the writer and is reported by Dr. Prouty as containing **Raphistoma** sp.

CORRELATION, BEEKMANTOWN LIMESTONE.

Both the Beekmantown proper and the lower beds which are herein regarded as Elbrook belong in the great series of dolomites or dolomitic limestones widely known in the central Appalachian region as the Shenandoah Limestone, following the early use of this title by Darton, and in the southern Appalachian States as the Knox Dolomite first described by Safford at a much earlier date. Although comprising a lithologic series of vast extent and great constancy both terms include rocks which are partly Ordovician and partly Cambrian in age and hence can scarcely be favored as desirable units for description or mapping.

In the portion of Mercer County embraced by the Pocahontas Folio the visible portion of these dolomites has been mapped by Campbell as the Shenandoah and in the adjoining Tazewell Folio immediately to the westward he also uses the same inclusive title but subdivides it into the following groups in descending oder:

Knox Dolomite
Nolichucky Shale
Honaker Limestone.

Campbell states in his description that the Nolichucky Shale feathers out and disappears in the Pocahontas region, allowing the series to become a single mass of limestone or dolomite.

Unfortunately there are no fossil lists in the Tazewell Folio for comparison with those of the present Report but the assemblage of dolomites may be followed so plainly along the northern front of East River Mountain that there does not appear to be much doubt that the Knox of the Tazewell Folio is the approximate counterpart of the Beekmantown proper as herein described and that the Honaker Limestone must closely represent the lower portion herein tentatively assigned to the Elbrook.

In a northeasterly direction the subdivisions of the Shenandoah have been described in the eastern Panhandle of West Virginia by Grimsley in the Jefferson, Berkeley, and Morgan

Report of the West Virginia Survey; by Bassler in the volume on the Cambrian and Ordovician Deposits of Maryland of the Maryland Geological Survey; and by Stose in the Mercersburg-Chambersburg Folio of the U. S. Geological Survey in eastern Pennsylvania. In this latter area a correlation of the upper portion with the Beekmantown Limestone of the Champlain Valley of New York, as first described by Clarke and Schuchert, is effected. Much of this same northeastern ground has also been covered by Ulrich in his Revisions of the Paleozoic Systems. The following generalized section of the Beekmantown in southern Pennsylvania and Maryland is published by Bassler on page 93 of the Maryland volume mentioned above, but is therein attributed by him to the descriptions of Ulrich although the actual section appears to have been compiled by Bassler. The total column at the right, however, is added by the writer for the sake of convenience:

Generalized Section of Beekmantown Limestone in Southern Pennsylvania and Maryland.

	Thickness. Feet.	Total. Feet.
Base of Stones River Limestone with quartz pebble conglomerate and cauliflower chert	..	..
Hard, dense, white chert and granular quartzose chert forming by secondary silicification, cauliflower chert	40	40
Fine-grained gray, finely laminated, interbedded pure and magnesian unfossiliferous limestone with sandy chert and limestone and dolomite conglomerates at top	400	440
Turritoma zone. Thin-bedded argillaceous and massive purer limestone containing the **Turritoma** fauna. Many of the beds weather so as to appear riddled with worm borings	200	640
Alternating beds of pure dove, pure gray and magnesian gray unfossiliferous limestone often laminated, with occasional beds of fine limestone conglomerate	300	940
Massive pure dove gray and magnesian limestone terminated above by sandy fossiliferous chert containing **Syntrophia lateralis, Maclurites sordida** and species of **Liospira**	75	1015
Ceratopea zone. Blue and dove fossiliferous limestone, cherty in the upper half, containing **Ceratopea** and associated fossils. At the base is a blue limestone filled with rounded quartz grains	250	1265

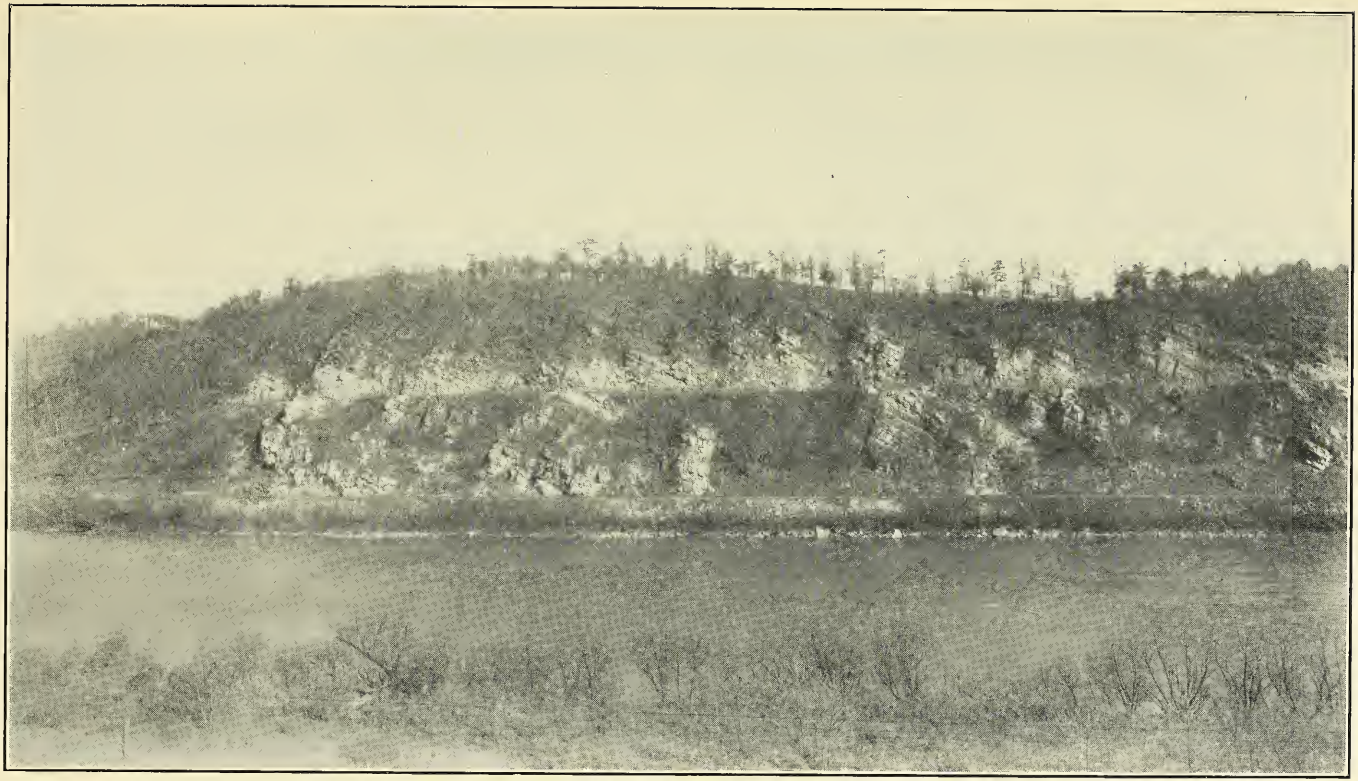


PLATE XXXIV.—Beekmantown Limestone on east side of New River, Giles County, Virginia, between Narrows and Rich Creek, looking eastward across New River. Highway cuts through middle of exposure and Virginian Railway skirts base. Exposure terminated at left by St. Clair Fault, followed by Devonian shales, the throw of the fault being nearly 5,000 feet. (Photo. by Palmer & Fowler).

	Thickness. Feet.	Total. Feet.
Cryptozoon steeli zone. Fine-grained nearly pure limestone with some magnesian beds and several layers of porous chert	275	1540
Dove, pink and bluish fine-grained pure limestone and marble	300	1840
Oolitic, cherty, blue and gray limestone holding the **Cryptozoon steeli** fauna and weathering into platy yellow chert	60	1900
Stonehenge limestone member. Massive dark blue to gray limestone with contorted argillaceous and siliceous laminations weathering to sandy shale, interbedded with edgewise beds and oolites	250	2150
Massive blue to gray pure limestone weathering white, with cephalopods and gastropods occurring in reef structures	250	2400
Top of Conococheague limestone with sandy laminae and beds of edgewise conglomerate	..	....

A comparison of the above section in the Potomac region with that for the local area of Mercer and Monroe Counties, pages 632-3, reveals several interesting points of similarity, the thickness of the Beekmantown proper in Mercer and Monroe being fortunately almost the same as in Maryland and Pennsylvania. At the top of the formation the same granular or finely pulverized chert is evident in both cases and is further shown by Bassler in other sections in Maryland. The writer has assigned the name of **Narrows Chert** to this member as will later be discussed in detail. In Mercer and Monroe pure limestones in the Beekmantown appear to be much less frequent than in the Potomac region but some are noted below the Narrows Chert. The presence of occasional quartz pebbles is noted in both sections, there being some interesting occurrences of pure, white quartz at 1300 feet below the top of the formation in Monroe County as compared to rounded quartz grains at 1265 feet in the Potomac region. The Stonehenge Limestone, coming near the base of the formation in Maryland, has not been certainly recognized in Mercer and Monroe by any of its pronounced eastern peculiarities nor by fossil contents.

The faunal relationships are more apparent from the context of Bassler's description than from the two sections, since nearly all the forms noted in Mercer and Monroe also occur

in the more northern States. There is a marked southwestward decline, however, both in the number of species and in the number of individuals, and this fact may account in part for the almost total absence of any record of fossils in the Knox Dolomite in folios describing the southern Appalachian States.

In the Potomac region the presence of **Cryptozoon steeli** is reported as almost wholly confined to one zone of the Beekmantown but in Mercer and Monroe these algae occur in some abundance throughout the whole Beekmantown proper. The greater range of these rather delicate bodies, combined with the virtual absence of the edgewise conglomerates which characterize the Beekmantown in Maryland, may indicate a generally more placid Beekmantown sea in southern West Virginia.

DESCRIPTION OF MEMBERS, BEEKMANTOWN LIMESTONE.

NARROWS CHERT.

The **Narrows Chert** (new) is a stratum of dolomite or dolomitic limestone carrying abundant quantities of gray or black cherts which weather into small angular or granular fragments somewhat after the fashion of blast-furnace slag. These cherts appear to be usually gray at the top but black toward the base and the gray fragments contain a rather constant fauna in which ramose bryozoa predominate. The total thickness of the member ranges from 200 to 275 feet, its occurrence being almost a constant feature in the two counties. The matrix, at the few points where it was observed, is a gray dolomite but it is seldom seen except at localities of recent excavation. In the Pocahontas Folio, however, Campbell states that there is red limestone visible in the top of the Shenandoah (Beekmantown) on Stony Creek near New River (presumably in Giles County) and says further that in the same locality there are conglomerate pebbles three or four inches in diameter. This colored aspect of the upper Beekmantown and of the Narrows Chert Member in particular was not noted in the local area, but on the east side of the

narrows of New River there are large chert pebbles in the cut of the Virginian Railway approximately 50 feet below the base of the Stones River Limestone.

The type locality of the Narrows Chert is in Giles County, Virginia, at elevation 2090′ B., on a low spur of Wolf Creek Mountain west of Mill Creek and south of Wolf Creek and about 2.2 miles southwest of Narrows. Here, as indicated in the Narrows Section, page 206, it is gray at the top but black at the base, generally weathering into small fragments but exhibiting cauliflower forms near the middle, and containing marine fossils throughout. **Fossil Lots 101, 102, and 103** were collected by Dr. Prouty and the writer as detailed in the section, the fauna including some undetermined species of bryozoa, mostly ramose in character, crinoid stems, and a brachiopod, **Hebertella** sp., according to the report of Dr. Prouty.

In Mercer County this chert is 283 feet thick southeast of Bluefield, as noted in the South Bluefield Section, page 631, being mostly black and weathering into small fragments. On the head of Big Spring Branch of East River 1.4 miles southeast of Pigeon Creek School and about 2½ miles southeast of Oakvale it is well exposed along a private road at elevation 2250′ B., being gray and finely weathering and having brachiopods. A little farther west on the same road there is black chert which appears to belong to this member.

In Monroe County the Narrows Chert may be noted at various points along the northern base of Peters Mountain. In the Hanging Rock Section, page 237, the upper zone of the Beekmantown, 160 feet thick, consists of gray dolomite with abundant scoriaceous chert and this horizon evidently is the Narrows Chert although not so named in the section. **Fossil Lot 69 on Map IV,** consisting of a single large specimen of **Maclurites** sp., was collected by Dr. Prouty and the writer. At this locality also the member contains **Cryptozoon** which would apparently dispose of any notion that the Narrows Chert might belong in the Stones River rather than in the Beekmantown.

ECONOMIC ASPECTS, BEEKMANTOWN LIMESTONE.

The Beekmantown Limestone weathers to a red soil that is well adapted for grazing. It also produces abundant crops but in general it is necessary to haul away great quantities of the almost indestructible chert blocks before it can be successfully tilled and there are also many large areas where the dolomitic masses remain unweathered, making waste land.

In Mercer County and in the portion of Giles County accessible to railroads the formation has been quarried extensively for railroad ballast, concrete aggregate and other purposes. Detailed descriptions of these quarries, together with chemical analyses and further comment, will be found in Chapter XIV under the subject of "Limestone."

In Tazewell County, Virginia, an extensive belt of barite is described by Campbell as occurring in the upper part of the Knox (Beekmantown) but these deposits are mapped as vanishing near the meridian of Tazewell, fifteen miles or more west of the Mercer County line. So far as known the mineral has not been observed in the Beekmantown of Mercer and Monroe Counties.

PART III.

Mineral Resources.

CHAPTER XIII.

PETROLEUM, NATURAL GAS, AND COMMERCIAL COAL.

PETROLEUM AND NATURAL GAS.

GENERAL STATEMENT.

The controlling factor in oil and gas accumulation in West Virginia is the Appalachian Geosyncline, or Basin, which enters the State near the southwestern corner of Pennsylvania, passes southwestward across it in a direction closely parallel to the Appalachian Mountains, and goes into Kentucky about 10 miles south of Kenova, Wayne County. Along this great structural depression, largely covered by rocks of Permo-Carboniferous age, there are abundant pools of both oil and gas in the minor folds, but in passing southeastward toward the mountain areas the oil pools become more scattered and of smaller size until finally this liquid is no longer found in commercial quantity. A similar southeastward decline occurs in gas, also, but in general the commercial disappearance of this commodity is 15 miles or more southeast of the last pools of oil.

The northwestern line of the local area of Mercer, Monroe, and Summers Counties is 85 to 90 miles southeast of the Appalachian Geosyncline and approximately 40 miles from the Cabin Creek Oil Pool of Kanawha County, but there are commercial gas wells in western Nicholas and northwestern Fayette Counties, only 25 to 30 miles from Summers County and in northern Wyoming County only 15 to 20 miles from the Mercer line. Southeast of the localities named the various tests drilled in intervening territory as well as in the three counties under study have made only trifling amounts of gas and oil or else have been wholly dry.

In Mercer County one deep hole and one comparatively shallow test have been drilled for oil; in Monroe no wells have been drilled although a derrick was once built in the vicinity of Cashmere; in Summers there have been four tests and one shallow hole. The results of the seven tests have been generally unfavorable, there being only a few small shows of gas and some slight traces of oil. In spite of these discouraging ventures, however, there are certain geological facts which favor the possibility, or even probability, that gas may be found in parts of these counties and which warrant a careful discussion of available data.

As a prospective oil or gas region the portions of Mercer and Monroe Counties south of the St. Clair Fault may be eliminated from serious consideration because of the fact that most of the known oil sands of North America belong above the topography or else outcrop in such a broken and disturbed manner that whatever deposits of this character they may have once held have, in all probability, escaped by surface evaporation in the form of gas. In portions of these two counties north of the St. Clair Fault, however, and in all of Summers County, the region is favored by a fringe of Pennsylvanian and by large and continuous bodies of Mississippian, Devonian, Silurian, and Ordovician Rocks, the shales and limestones of which are known to contain abundant vegetable and animal remains from which oil and gas are admittedly distilled. It is further favored by folding which has developed well-defined anticlinal and synclinal structure so that any

liquid hydrocarbon formed at an early age could have been fully segregated into pools. It is favored, moreover, by location at only a moderate distance from the vast petroliferous province above mentioned to which it is connected by presumably porous strata, and from which gaseous substances, especially, might be expected to migrate in the effort to relieve natural rock pressure.

In some other fundamental conditions, however, this region is lacking. The Pennsylvanian beds occupy only certain plateau areas along the western edges of Mercer and Summers Counties and the northern edge of the latter, their sands being exposed to the atmosphere for long distances. The Mauch Chunk Series of the Mississippian, also, is almost cut through by some of the major streams of Mercer and Summers and is entirely above drainage in a considerable portion of Monroe, and the Greenbrier Series of the same period forms the surface of a considerable part of the latter county, so that none of these upper beds could be expected to have production over extensive areas.

A further vital condition is that the folding which formed the various ridges of the Alleghenies has been so severe that incipient metamorphism has taken place, which, with its attendant great heat and pressure, may have completely volatilized the hydrocarbons, causing their escape from the rocks in gaseous form. It has been established by Dr. David White of the United States Geological Survey that oil is seldom found in regions where the coals have extremely low volatile and high carbon content, and that gas in such localities is less abundant than in areas where the relative percentage of carbon is smaller, the explanation being that the analysis of the coal reveals the extent to which metamorphism has advanced and gives a criterion by which the same process in the petroleum hydrocarbons may be roughly measured. A carbon ratio for any point may be obtained by dividing the fixed carbon of the proximate analysis of a local coal by the sum of the fixed carbon and the volatile matter of the same analysis, which gives the total carbon contained in the coal on a moisture free basis. Isocarbs, or lines of equal carbon, may then

be obtained by computing the carbon ratios for many points of a given area so that lines of average equal content may be drawn, making available the approximate ratio for any position. A map of this sort recently prepared for the whole State of West Virginia by the writer has shown rather conclusively that oil is found in the State principally in regions where the isocarbs indicate a ratio of less than 60, there being a few good pools between 60 and 65, and that gas in quantity has seldom been found where the ratio is above 70.

In Mercer the average carbon ratio of 17 samples of No. 3 Pocahontas Coal in the western edge of the county is 77. In Monroe the average of five samples of the Merrimac Coal of Pocono age, secured from prospects in Little Mountain and Cove Mountain, is 72, but the sample obtained in Cove Mountain is regarded as unreliable and it is probable that the average of 79 obtained from the four samples in Little Mountain is a better index of true conditions. In Summers the average of one sample of No. 6 Pocahontas and one sample of No. 3 Pocahontas in Hump Mountain at the northern edge of the county is 79. These high averages make the occurrence of oil quite improbable in the three counties and indicate that the search for gas will be a hazardous venture.

OIL AND GAS HORIZONS.

The following classification of the various oil and gas sands of the State, taken with slight revisions from former Reports of the Survey, gives the productive horizons of other counties, including some that have produced oil in northwestern Pennsylvania but may not yet have yielded commercial quantities in West Virginia, as well as the deeper horizons of Ohio and Kentucky some of which are now being sought for at great expense in various parts of the State. In this table the sands are grouped under the formation names, the titles in use by the drillers being given preference, followed in most cases by their geologic equivalents:

Oil and Gas Horizons of West Virginia.

Pennsylvanian:

Monongahela Series.....	Carroll Sand (Uniontown).
Conemaugh Series.....	Minshall Sand (Connellsville). Murphy Sand (Morgantown). Moundsville Sand (Saltsburg). First Cow Run (Little Dunkard) Sand (Buffalo). Big Dunkard Sand (Mahoning).
Allegheny Series	Burning Springs Sand (Upper Freeport). Gas Sand of Marion and Monongalia Counties (Lower Freeport).
Pottsville Series.....	Second Cow Run Sand of Ohio (Homewood). Cairo Gas Sand. Cairo Salt Sand. Cairo? Rosedale Gas Sand (Guyandot). Rosedale Salt Sand (Sharon Conglomerate). Breeden Sand (new) of Mingo County.

Mississippian:

Mauch Chunk Red Shale Series	Princeton Conglomerate. Maxton (Droop?) Dawson. Little Lime.
Greenbrier Limestone Series	Big Lime.
Pocono Sandstone Series....	Keener Sand and Beckett Sand of Milton. Big Injun Sand (Logan). Squaw Sand. Weir Sand (Broad Ford). Berea Sand.

Devonian:

Catskill Red Beds.....	Gantz Sand. Fifty-foot Sand. Thirty-foot Sand. Gordon Stray Sand. Gordon Sand. Fourth Sand. McDonald or Fifth Sand. Bayard or Sixth Sand. Elizabeth or Seventh Sand (Hendricks).

Chemung and Portage Beds..	Warren First Sand. Warren Second (Burnside?) Sand. Clarendon or Tiona Sand. Speechley Sand. Balltown or Cherry Grove Sand. Sheffield or Cooper (Riley?) Sand. Benson, Bradford? or Deer Lick Sand. Elk or Waugh and Porter Sand. Kane Sand.
Genesee Shale.....	Childress Sand (new) of Cabell County.
Hamilton and Marcellus.....	Gas in Ohio and Kentucky.
Corniferous (Columbus) Limestone	Ragland, Menefee, or Irvine Sand of Kentucky.
Oriskany Sandstone.....	Oriskany Sand.
Devonian and Silurian:	
Helderberg (Devonian), Salina and Niagara (Silurian)	"Big Lime" of Ohio (Newburg Sand near middle).
White Medina Sandstone....	Clinton Sand of Ohio.
Ordovician:	
Martinsburg or Cincinnati Series	Hudson Sand Group of Kentucky.
Trenton and Other Limestones (partly Martinsburg Series).....	Trenton Sand Group of northern Ohio.

In the three counties under study the known productive sands of the Monongahela, Conemaugh, and Allegheny Series do not exist at all as they belong above the tops of the mountains. Only small areas of the Pottsville, also, remain and these areas are so much exposed to evaporation that they may be eliminated from serious consideration as local oil or gas horizons. A new productive stratum, coming just above the Mauch Chunk reds, and apparently having an abundant content of oil near Breeden, Mingo County, is herein designated as the **Breeden Sand,** its more particular correlation being still uncertain. In the Mauch Chunk Series there are many porous sands but these rocks outcrop widely and do not offer much hope of oil or gas, although they might be regarded with some slight favor in the northwestern portions of Mercer and Summers Counties. This series, moreover, has a very

great local thickness, varying from 2,000 to 3,400 feet, and makes a decided obstacle in attempting to reach lower and more hopeful sands.

The Greenbrier Limestone Series, or Big Lime, varies in thickness from 700 to 1,800 feet in the three counties, and in northern Mercer and nearly all of Summers Counties is buried under a protective mantle of Mauch Chunk. At its outcrop farther south and southeast, however, this calcareous assemblage shows only fragmentary lenses of sandy material and is never sufficiently dolomitic to be regarded as a porous reservoir. If this high lime content were known to continue through all its underground area the series would be an improbable source of gas but it is known to contain sandy beds elsewhere that extend over wide areas and some of these may possibly occur in portions of Mercer and Summers Counties.

The Pocono Series, which in most of West Virginia occurs just under the Greenbrier but which in the local area is separated from the limestone by the Maccrady Series of red shales as shown by Figure 6, page 131, contains several coarse and porous sandstones and is entirely under drainage in northern Mercer, northwestern Monroe and in all of Summers County. The sands of this series may be regarded as among the most hopeful of the local area.

The Catskill Series, which contains the Venango Group of oil and gas sands of Pennsylvania and northern West Virginia, is totally absent from the three counties, allowing the Pocono to rest directly on the Chemung. The Chemung and Portage beds which generally consist of thin, flaggy sandstones separated by sandy shales, and which contain several known productive sands in Pennsylvania and a few in West Virginia, usually outcrop just north of the St. Clair Fault and then pass deeply below drainage in the more northern areas, except that in eastern Monroe County the Chemung remains above drainage farther north as shown by Map IV. In southeastern Monroe there is a heavy conglomerate (Lackawaxen?) near the top of the Chemung which would be a porous medium in the region where the series is buried provided this pebbly condition continues.

The Genesee Shale, which has not generally been productive, has lately developed a profitable gas horizon, herein termed the **Childress Sand** from the discovery well, Thomas Childress No. 1 of the Commercial Gas Company, at Sarah, Cabell County. This formation is usually a dark brown or black shale without any bedded sandstones but is evidently porous at some localities. It passes beneath drainage just north of the St. Clair Fault and so remains in the principal areas of the three counties but at many points along its line of outcrop it was not definitely recognized.

The Hamilton and Marcellus, composed of sandy and dark shales with a little limestone, produce some gas in Ohio and Kentucky but are not yet known to have gas or oil in West Virginia. These also pass under drainage at the St. Clair Fault and become deeply buried farther north. The Corniferous Limestone, known as the Ragland, Menefee, or Irvine Sand in Kentucky where it is cherty and porous and contains oil and gas, has not been definitely recognized at any outcrop in West Virginia and probably does not occur in much underground territory, the dark, non-porous limestone which has been occasionally referred to this horizon in deep wells being most probably the Lower Selinsgrove Limestone of the Marcellus Series.

The Oriskany Sandstone is beneath drainage at nearly all points north of the St. Clair Fault and in counties farther north is generally quite porous. At its principal outcrops in Potts Valley of Monroe County it is quite dense and quartzitic, showing many evidences of metamorphism. It is not likely that such an unfavorable condition prevails in all the territory where it lies buried north of the fault although it is probably more dense than in many other counties.

The collection of limestones, known as the Big Lime of Ohio and comprising the Helderberg of Devonian age and the Salina and Niagara of the Silurian, are almost totally absent at outcrops in the three counties, there being only a remnant of the Helderberg at a few localities. This group offers little hope of oil or gas.

The White Medina Sandstone, which is known as the

"Clinton" Sand in southeastern Ohio where it has produced much oil and gas, outcrops in the summits of East River Mountain and Peters Mountain and also in Potts Valley, being 50 to 150 feet thick but extremely quartzitic and hard. In the region north of the St. Clair Fault it is deeply buried at nearly all points except along Gap Mountain, Monroe County, but its pore space has probably been greatly reduced by lateral pressure. Even at favorable anticlinal localities in some of the deep valleys it could hardly be reached without drilling 5,000 to 6,000 feet.

The Trenton Limestone, comprising the lower portion of the Martinsburg Series and being a highly productive horizon in northern Ohio, outcrops along the northern fronts of East River Mountain and Peters Mountain, and at a few points in Potts Valley and also north of the St. Clair Fault on the southern slope and near the western end of Gap Mountain. At the best exposures of this limestone, in the narrows of New River, it is a thin-bedded and largely crystalline deposit without much evidence of dolomitization. Farther up in the Martinsburg Series, however, there are some sandy beds in the Lower Maysville Group that would probably be porous. The top of this series would be 500 feet or more beneath the base of the White Medina so that deep drilling would be required to reach it in the region north of the St. Clair Fault.

WELL RECORDS, MERCER COUNTY.

In Mercer County only two wells have been drilled for oil, neither of which obtained production. The following is a deep test, the partial record of which was published by C. E. Krebs in the Raleigh County Report of the Survey, pages 375-377, being still uncompleted when the volume was issued. Mr. Krebs has very kindly furnished the remainder of this record and it is herein published in full, the formations being correlated by the writer, as follows:

Owen Griffith No. 1 Well Record (1).

Rock District, Mercer County; on Rich Creek 1.4 miles west of Spanishburg; authority, Rich Creek Oil and Gas Company; began drilling in December, 1915; elevation, 2075′ B.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluestone Group (53′)		
Clay	16	16
Lime, hard	35	51
Coal?	2	53
Mauch Chunk Series—Princeton Conglomerate (52′)		
Sand, Princeton	52	105
Mauch Chunk Series—Hinton Group (1253′)		
Slate	35	140
Lime, dark, hard	12	152
Slate	42	194
Lime (hole full of water at 220 ft.)	41	235
Red rock	45	280
Lime, white	15	295
Lime, dark	50	345
Slate, soft	1	346
Lime, hard	14	360
Slate	4	364
Shells	4	368
Slate	27	395
Lime	50	445
Slate	20	465
Lime, **Avis**	45	510
Red rock	230	740
Lime	40	780
Red rock and shells	50	830
Lime	40	870
Red rock	2	872
Lime	52	924
Red rock and shale	81	1005
Lime (8″ casing, 1069 ft.)	48	1053
Red rock	10	1063
Lime	20	1083
Red rock	12	1095
Lime	39	1134
Slate, black	20	1154
Sand, Lower Bellepoint	46	1200
Slate	28	1228
Lime, very hard	22	1250
Red rock	8	1258
Sand, Stony Gap, very hard, pebbly	100	1358
Mauch Chunk Series—Bluefield Group (1292′)		
Red rock and slate	42	1400
Sand, Clayton	13	1413
Slate and shells	52	1465
Red rock	10	1475
Lime	10	1485
Red rock	40	1525
Lime shells	60	1585
Slate, black, **Graham Coal** horizon	25	1610
Sand, Bertha	56	1666
Shells and black slate	144	1810
Slate, dark	130	1940
Shells	45	1985
Lime, dark	55	2040
Slate, light	20	2060

	Thickness. Feet.	Total. Feet.
Slate and shells	180	2240
Sand, pebbly, Droop; probably Maxton	4	2244
Lime	81	2325
Slate and shells	85	2410
Lime, dark, Ada	15	2425
Red rock, Bickett Shale	11	2436
Lime, Glenray, Little Lime	64	2500
Lime, black, Lillydale Shale or Pencil Cave, horizon	150	2650
Greenbrier Series, Big Lime (1595')		
Lime, white	65	2715
Red rock	11	2726
Slate, black	5	2731
Lime, white	69	2800
Slate, black, and shells	30	2830
Slate and shells	75	2905
Lime, white	27	2932
Lime, black	66	2998
Lime, broken	106	3104
Red rock	15	3119
Lime, gritty	61	3180
Lime, gritty	110	3290
Slate and lime shells	73	3363
Lime, pink	49	3412
Lime, sandy, hard	44	3456
Slate and sand shells	104	3560
Lime, sandy	17	3577
Slate and shells	88	3665
Sand, hard	41	3706
Slate, dark	3	3709
Lime, hard, gritty	43	3752
Slate, light, soft	9	3761
Lime, gritty and slaty	21	3782
Lime, sandy, very hard	12	3794
Slate, soft shells	76	3870
Lime, hard	25	3895
Slate	35	3930
Lime	10	3940
Slate and small shells (May 29, 1916)	165	4105
Lime, white	19	4124
Sand	12	4136
Slate, blue	49	4185
Lime, black, hard	40	4225
Lime, white	20	4245
Maccrady, Pocono, and Chemung? Series (766')		
Slate, white	15	4260
Slate	20	4280
Slate, black	20	4300
Lime, black, hard	20	4320
Slate, hard, and shells	32	4352
Lime, white	58	4410
Shale, hard, and slate	176	4586
Lime, gritty	14	4600
Slate	25	4625
Lime, hard	14	4639

	Thickness. Feet.	Total. Feet.
Slate and shale	61	4700
Lime	75	4775
Slate	10	4785
Lime, white	85	4870
Slate, blue	13	4883
Lime, white	17	4900
Slate, white	20	4920
Slate, blue, to bottom	91	5011

"Dry in all formations."

In the above well, which appears to have been totally dry in all sands, the record is difficult to correlate because the drillers have called many formations lime which are probably only hard shale or fine-grained sandstone but in the Mauch Chunk Series the relationships are fairly plain. Farther down it is evident that the Pocono was quite shaly, as is the case at Bluefield where the Big Injun, Squaw, and Berea Sands are all absent. The well location was near the southern end of the shallow Bellepoint Syncline.

The **Isaiah Bee No. 1 Well (2),** located at the southern edge of the city of Princeton and just north of Brush Creek, Beaver Pond District, was drilled by Robert Crenshaw et al. about the year 1902, and according to Mr. E. L. Day, Manager of the Princeton Water Works Company, it had a total depth of about 1,600 feet, there being water at 480 feet which contained sulphur and iron and salt water at 1,500 or 1,600 feet. From one of these horizons the well made an artesian flow. Apparently no oil or gas was found. This hole starts at elevation 2390′ B. and probably about 125 to 150 feet above the top of the Princeton Sandstone, and hence may have penetrated the Stony Gap Sandstone.

The following well, although drilled for water instead of oil, is of much stratigraphic interest, the record being furnished by Mr. Day:

Princeton Water Works Company No. 5 Well Record (3).

Beaver Pond District, Mercer County; on west side of Virginian Railway 0.7 mile south of Princeton Station; authority, Princeton Water Works Company; completed, October 15, 1921; elevation 2385′ B.

	Top. Feet.	Bottom. Feet.
Soil	0	7
Shale	7	145
Sandstone, Princeton (water, 180′)	145	180
Shale	180	192
Coal, Pluto, streak	...	...
Shale	192	210
Sandstone, hard	210	223
Shale, black, to bottom	223	225

The above record indicates the rapid southward dip of the rocks, the Princeton Sandstone being above drainage just north of Princeton Station.

PROSPECTIVE GAS AREAS, MERCER COUNTY.

In the northwestern corner of Mercer the Dunn Anticline extends into the county eight or ten miles, as shown by Map II, but at the southern end is quite flat and may or may not be reflected in the deep oil sands. Toward the Summers County line it rises and becomes sharper. At the point where this anticline crosses Oldhouse Branch of Mountain Creek just north of Dunn the Avis Limestone is probably less than 100 feet below drainage and a test would reach the Stony Gap Sandstone at 800 feet or less, the Droop Sandstone (Maxton Sand?) at about 1,500 feet, and the top of the Greenbrier (Big Lime) at something like 1,800 feet. This limestone is probably 1,000 to 1,200 feet thick at Dunn so that it would require about 3,000 feet of drilling to reach the Pocono Series which contains the Big Injun and other principal gas sands of southern West Virginia. Aside from the favorable structure there is little evidence that such a test would be successful.

Farther south in Mercer the Abbs Valley Anticline, which is a bold uplift starting with an overthrust fault in southwestern Virginia but gradually losing this feature and becoming a sharp anticline, as previously described on pages 142-146, apparently offers a much more favorable region for attempting to find gas. On the approximate axis of this arch just southwest of Sandlick Creek and 0.8 mile north of Sandlick village there is a considerable gas seepage on the land of John J. Sheppard, coming out of the Alderson Limestone of the Green-

brier Series which is sharply folded, as illustrated by Plate XX, on Sandlick Creek. At this seepage gas flows from the end of a rubber tube inserted into the ground about 2½ feet and when lighted burns with a flame one foot high. The gas is also said to seep out at near-by points and also at another locality or two along the anticline according to reputable witnesses.

The high part of this anticline in Mercer County, as shown by Map II, extends from the Virginia State line near Nemours northeastward for 13 miles to the end of Blackoak Mountain southeast of Kegley beyond which it perceptibly flattens. A test on Bluestone River just southwest of Nemours village would start 200 feet or more below the top of the Greenbrier Series and should reach the Pocono Series at about 1,500 feet and the Oriskany Sandstone at less than 4,000 feet and the White Medina Sandstone ("Clinton Sand") at 4,500 feet or less. Much the same intervals would be found at a location near the Sheppard seepage on Sandlick Creek except that the hole would start near the top of the Greenbrier, which might, however, be slightly thinner than at Nemours. On Blackoak Mountain southeast of Kegley a well would start about the top of the Stony Gap Sandstone of the Mauch Chunk Series and would require 1,000 to 1,200 feet more of drilling to reach the same sands than at the two other localities mentioned. There would naturally be a large element of risk in testing this anticline so near the mountains and so far from other gas production so that the venture should preferably be left to some large corporation having ample funds for exploration purposes.

East of Athens toward New River the Abbs Valley Anticline again rises toward a dome which occurs farther east in Monroe County. In the edge of Mercer the most favorable point for drilling would be found in the head of the northern branch of Roundbottom Creek about one mile west of Lovern where a hole could be started about 100 feet below the base of the Stony Gap Sandstone and would probably reach the top of the Greenbrier at slightly more than 1,000 feet, the intervals to the deeper sands being about as above mentioned.

WELL RECORDS, MONROE COUNTY.

In Monroe County no tests for oil and gas have been completed. A derrick, located on the **Mary Hughes** farm one-fourth mile south of Cashmere and just north of Brush Creek, was once built by Morgan, Barger, et al. of Huntington and Charleston and was still standing in 1922 but no drilling had been done. This location is about midway between the Abbs Valley Anticline and Hurricane Ridge Syncline and near the top of the Stony Gap Sandstone.

PROSPECTIVE GAS AREAS, MONROE COUNTY.

In Monroe it is not probable that capital could be induced to drill for gas at any locality southeast and east of the Hurricane Ridge Syncline, which roughly divides the area of the county in half, the rocks being generally too much disturbed and faulted and there being wide areas over which the known oil sands of the State have been eroded. West and northwest of this syncline, however, there are structural folds in which it is possible that some deposits of gas may still be trapped, although there is no great probability that such is the case.

On the Sinks Grove Anticline, the axis of which rises toward the north, it would be possible to start a hole several hundred feet below the top of the Pocono Series along the Monroe-Greenbrier County line on Second Creek between Nickells Mill and Hokes Mill. At such a location the Oriskany Sand would probably be reached between 3,500 and 4,000 feet and the White Medina ("Clinton") between 4,500 and 5,000 feet. If an initial test proved the presence of gas, drilling could then be extended southward along the anticline toward Bickett Knob.

On the Abbs Valley Anticline there is a dome in the vicinity of Johnson Crossroads where a hole could be started at the approximate level of the Taggard Limestone of the Greenbrier Series and should reach the top of the Pocono Sandstone Series at about 500 feet and the Lackawaxen Conglomerate of the Chemung at about 1,200 feet, while the Oris-

kany would probably be considerably more than 4,500 feet and the "Clinton" in the neighborhood of 5,500 feet. Farther southwest along the same anticline a dome occurs in the vicinity of Chestnut Hill (Bozoo Post-office) five miles northward from Peterstown. Here the Stony Gap Sandstone of the Mauch Chunk Series forms the surface of the plateau so that it would be about 1,200 feet to the top of the Greenbrier, about 2,700 feet to the top of the Pocono, probably 4,500 feet to the Oriskany, and 5,000 feet or more to the "Clinton".

Along the Alderson Anticline in the vicinity of Alderson or at Wolf Creek Station holes could be started about 100 feet below the top of the Greenbrier and should reach the top of the Pocono at about 1,000 feet, the Lackawaxen Conglomerate at about 1,700 feet, the Oriskany at 4,500 feet or less, and the "Clinton" at 5,000 feet or more.

WELL RECORDS, SUMMERS COUNTY.

In Summers County there have been four deep tests for oil and gas and one shallow hole, besides a few water wells which are of some interest. In Green Sulphur District the **W. L. Fleshman Water Well (10)**, drilled about 1900, or perhaps 1902, in the village of Elton on Mill Creek and having a depth of only about 40 feet, still flows a small supply of gas, possibly enough to supply a cook-stove if carefully cased and packed. This hole started at elevation 1750′ B. just below the base of the Middle Bellepoint Sandstone in the lower part of the Hinton Group of the Mauch Chunk Series and probably obtained its gas in the Lower Bellepoint. According to residents two or three other shallow holes were drilled at this same locality, one of which contained a little oil, but further details are lacking.

In the same district the **James H. Gwinn No. 1 Well (11)**, located on the south side of Lick Creek just opposite the mouth of Mill Creek and one-half mile south of Green Sulphur Springs and starting at elevation 1545′ L., was completed by the Green Sulphur Oil and Gas Company April 16, 1914, with a total depth of 3,000 feet. Shows of gas were reported at

2,100 feet, in shells just below the Weir Sand and probably more properly belonging to that formation, and at 2,365 feet and 2,825 feet, in the shaly strata of the Chemung Series, but the hole was abandoned. When visited by the writer in 1922 there was a strong stream of salt sulphur water flowing from the 14-inch casing which is still in the hole, there being numerous bubbles of a non-inflammable gas. The record of this well is published as part of the Green Sulphur Springs Section, page 239 of this Report, and has been previously published in other Reports as already enumerated.

In Jumping Branch District the following deep test was drilled near Hinton, as previously published by C. E. Krebs in the Raleigh County Report of the Survey, pages 88-89, in connection with a surface measurement. Certain revisions in correlation have been made by the writer in accordance with the much more detailed knowledge of the Mississippian Series now available:

B. T. Baker No. 1 Well Record (12).

Jumping Branch District, Summers County; on Beech Run of New River 2½ miles southwest of Hinton; completed in 1914; authority, Summers Oil and Gas Company; elevation, 1586′ L.

	Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Hinton Group (100′)		
Conductor	23	23
Lime (probably **Stony Gap Sandstone**)	77	100
Mauch Chunk Series—Bluefield Group (920′)		
Red rock	70	170
Lime	15	185
Red rock	125	310
Lime	40	350
Red rock (gas, 385′)	150	500
Sand, **Indian Mills**	20	520
Lime	30	550
Slate	10	560
Lime	40	600
Red rock	25	625
Lime, **Raines Corner**	25	650
Slate, black, **Raines Corner Coal** horizon?	80	730
Sand, **Maxton, (Droop)**	20	750
Little Lime (Glenray Limestone)	170	920
Slate, **Pencil Cave (Lillydale Shale)**	100	1020

Greenbrier Series (1057′)				
Lime, white	130′			
Lime, black	130			
Lime, brown	320			
Lime, white	205			
Lime, black	52			
Lime, white	43	**Big Lime** (gas, 1085′ and 1900′)	1057	2077
Lime, black	82			
Sand	8			
Lime, gray	45			
Lime	10			
Lime, blue	27			
Lime, black	5			
Maccrady Series (58′)				
Red rock			13	2090
Sand, white			7	2097
Red rock			38	2135
Pocono Series (490′)				
Sand, gray	10′			
Sand, white	10	**Big Injun Sand**	61	2196
Sand, red	10			
Sand, gray	31			
Slate, black			14	2210
Slate and shells			20	2230
Sand, gray, **Squaw**			15	2245
Slate, black			5	2250
Slate and shells			24	2274
Slate, black, **Merrimac Coal** horizon			6	2280
Slate and shells			15	2295
Sand, gray	15′			
Slate, black, and shells.	10	**Lindside Sandstone**	35	2330
Sand, gray	10			
Slate, black, **Langhorne Coal** horizon			13	2343
Slate and sand shells	47′			
Lime, gray, sandy	55	**Weir Sand (Broad Ford Sandstone)**	125	2468
Sand and slate shells	23			
Lime, gray, sandy			42	2510
Slate and lime shells			90	2600
Sand, hard, black	10′			
Lime, gray, sandy	15	**Berea Sand**	25	2625
Chemung Series (39′)				
Slate and shells			39	2664

No information is afforded as to the amount of gas actually found in the above well but it was abandoned as a dry hole and presumably the shows were small.

In Talcott District the **James Warren No. 1 Well (13)**, located on the southeast side of Greenbrier River at Riffe at elevation 1505′ B., and starting 45 feet below the top of the Greenbrier Series, was drilled by a local company in which Capt. M. Warren, the father of the present landowner, was

reported to have been actively interested. A letter addressed to Mr. James Warren, however, elicited no reply and little information on the well is available from any other source, although the well was said to have been drilled about 2,000 feet deep and then abandoned on account of a disagreement with the contractor. In 1922 there was a 13-inch pipe in the hole from which a considerable stream of slightly sulphurous water, said to be intermittent, was flowing. A hole 2,000 feet deep at this locality would pass through the horizon of the Berea Sand and into the Chemung Series. Mr. C. E. Krebs, however, states in the Raleigh Report of the Survey, page 378, that Capt. Warren reported the hole as about 3,000 feet deep with considerable gas in the Big Lime.

In Pipestem District the **George Harmon No. 1 Well (14),** located in Crumps Bottom south of New River and 1.6 miles east of Warford at elevation 1430′ B., was drilled to a depth of 3,000 feet, according to the record furnished by Mr. Charles H. Mellon of Philadelphia, Pa., and as published by Dr. I. C. White in Volume I(a) of the Survey. This record has been republished as part of the Warford Section, page 261 of this Report, with certain changes in correlation made possible by present information. The bottom of the hole was apparently 25 feet below the base of the Berea Sand, there being a little gas near the top of the Big Injun Sand, although the well was abandoned as a dry hole.

In the same district the **Jabez Anderson No. 1 Well (15),** located on the north side of Lick Creek one-half mile west of Mercers Saltworks, with a surface elevation of 1500′ B., was drilled about the year 1860 by Charles Clark and others of Kanawha County. According to J. Anderson, present owner of the land and a grandson of Jabez Anderson, the well was drilled about 1,100 feet deep and had a little gas, being abandoned as an unproductive venture. The hole starts 30 or 40 feet below the base of the Stony Gap Sandstone of the Hinton Group of the Mauch Chunk and probably did not quite reach the Greenbrier Series.

The **Jabez Anderson Salt Well (16),** located in the bottom just south of the oil test and starting at the same topographic

and stratigraphic level, was also drilled by Clark and his associates about the same time as the oil well and reached about the same depth. According to J. Anderson, salt brine was found at an unknown level and the product was manufactured into salt for a time by Jabez Anderson but the plant was burned during the civil war and was not rebuilt.

PROSPECTIVE GAS AREAS, SUMMERS COUNTY.

In the northwestern part of Summers County the Boggs Knob Anticline of Fayette County passes into the territory for about 10 or 12 miles and offers some slight hope that gas might be trapped although the reversal of dip is generally little more than 50 feet. In the vicinity of Lockbridge there appears to be a slight dome and this locality, from a theoretical standpoint, would be the most favored place for a test. As a practical matter, however, there should also be gas at other points along the arch provided it is present at Lockbridge so that it would probably be better to drill on Lick Creek, Laurel Creek, or on New River where an advantage of 1,000 feet or more would be gained by the deep valleys. At the point where the anticline crosses New River 1.2 miles northwest of Brooks, a hole could be started about 50 feet below the base of the Stony Gap Sandstone and should reach the top of the Greenbrier Series at 800 to 900 feet, and the top of the Pocono at 1,700 to 1,800 feet, and the Berea Sand at probably about 2,200 feet. Depths to the Oriskany and "Clinton" could hardly be predicted with any certainty on account of the unknown thicknesses of the Devonian and upper part of the Silurian in that region. On Laurel and Lick Creeks holes would start at slightly higher stratigraphic levels but there would be compensation in the northward thinning of the rocks so that drilling depths to the Berea Sand would be about the same as on New River.

On the Dunn Anticline, which crosses New River between Hinton and Bellepoint, a well (No. 12 on Map VI) has already been drilled through the Berea Sand, its location being on a low, closed dome. There is some slight possibility of gas in

the deeper sands, however, the depths to these on the arch along New River being much the same as above outlined near Brooks.

In the eastern edge of the county in the vicinity of Lowell, Riffe, and Wolfe Creek Station the Alderson Anticline makes a considerable arch, partly in Summers and partly in Monroe County, its crest occupying comparatively low ground at several points along or near Greenbrier River, with exposures of the upper part of the Greenbrier Series. The probable depths to various sands at Wolf Creek Station have already been mentioned under the discussion of Monroe County, page 660. Farther southwest an advantageous point for testing the deep sands would be on Wind Creek one-half mile or more southeast of Lowell where a hole could be started in the top of the Greenbrier Series and should reach the top of the Pocono at about 1,000 feet, the Lackawaxen Conglomerate at about 1,700 feet, the Oriskany at about 4,500 feet, and the "Clinton" at 5,000 feet or more. The arch at this locality flattens into a terrace after a considerable rise northeastward from the vicinity of Bargers Springs.

In the extreme southern end of the county the Abbs Valley Anticline crosses New River one-half mile northeast of Lovern and makes an elongated closed dome, the top of which is near Chestnut Hill (Bozoo Post-office) two miles farther northeast in the edge of Monroe County. On New River, however, a location could be made within the closure and only about 100 feet lower on the structure than at Chestnut Hill and could be started about 600 feet deeper in the rocks. Here it would be about 600 feet to the top of the Greenbrier, about 2,100 feet to the top of the Pocono, probably slightly less than 4,000 feet to the Oriskany, and only about 4,500 feet to the "Clinton". All these formations outcrop in the narrows of New River, seven miles or less to the southward, these exposures being separated from the Abbs Valley Anticline by the deep Hurricane Ridge Syncline. There would naturally be much risk in drilling so near the mountains although the structural layout is almost ideal.

COMMERCIAL COAL.

GENERAL STATEMENT.

In the three counties under study commercial coals are found only in the Pottsville Series of the Pennsylvanian Period, and these are confined to the western edge of Mercer County and the western and northern edges of Summers County, there being no Pottsville in Monroe County. In the Mauch Chunk and Pocono Series of the Mississippian Period there are thin and impure coals in all three counties as already discussed and described in Chapters VII and IX where various detailed exposures have been indicated.

Of the 17 Pottsville coals which occur in parts of Mercer or Summers there are four which appear to have a definite minable value in some localities, six others which crop too near the summits of the mountains or which are too lenticular for dependable mining, and seven which are only thin streaks or markers.

Figure 23 shows the different coal seams of the Pottsville in the two counties, giving not only their relative thickness but also the usual intervals (base to base) between them. The four seams regarded as minable in some localities and named in descending order are the No. 8 Pocahontas of the New River Group; and the No. 6 Pocahontas, No. 3 Pocahontas, and No. 2 Pocahontas of the Pocahontas Group. These four coals, only, will be given tonnage estimates in the present discussion, brief mention being made of certain others, while the remaining small seams of the Pottsville have already been described in Chapter VI so far as they pertain to the territory of this Report.

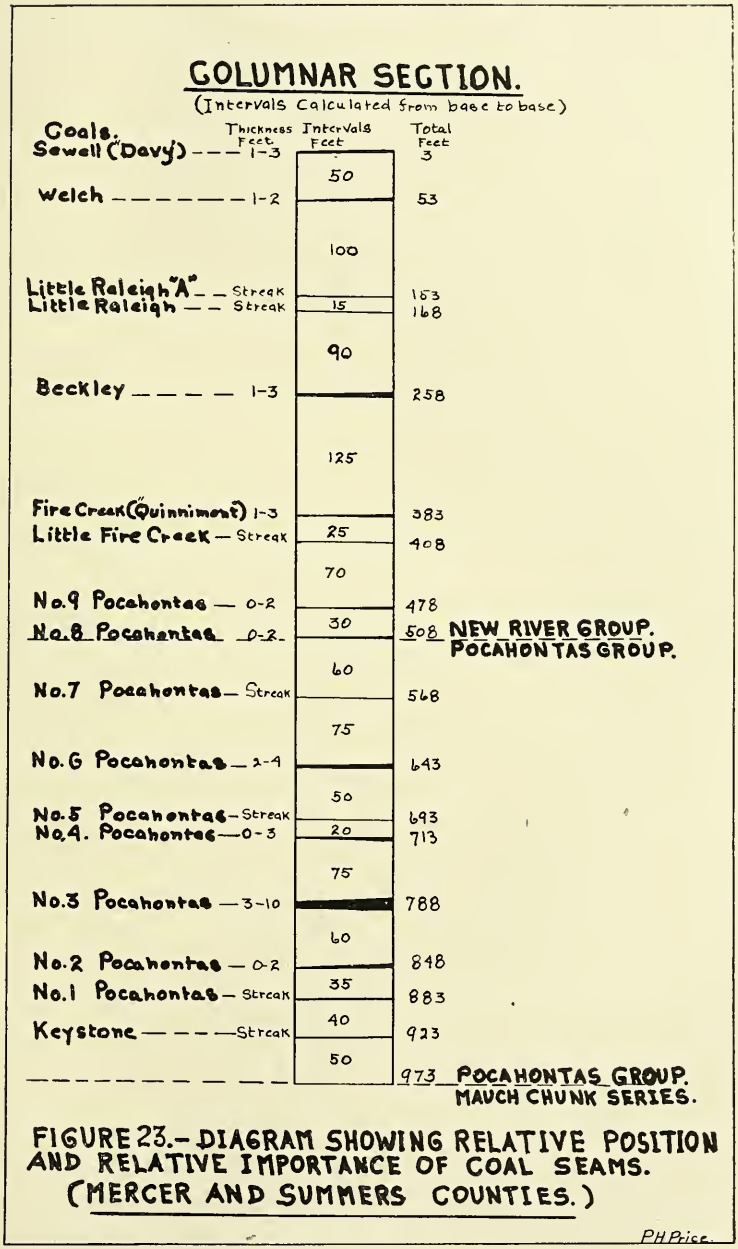


FIGURE 23.—DIAGRAM SHOWING RELATIVE POSITION AND RELATIVE IMPORTANCE OF COAL SEAMS. (MERCER AND SUMMERS COUNTIES.)

PH Price.

On page 1 and elsewhere in this volume it has already been mentioned that a study of the geology and more especially of the coals of Rock and Jumping Branch Districts, Mercer County, and Jumping Branch District, Summers County, has been previously made by C. E. Krebs and his assistant, D. D. Teets, Jr., their detailed description of mines, chemical analyses, and estimates of tonnage and other data having been published in the Report on Raleigh County and the Western Portions of Mercer and Summers Counties in 1916. In the Atlas which accompanies the present Report the outcrops of the coals in these three districts, as determined by Krebs and Teets, have been repeated on Maps II and VI, as the case may be, and also the numbered locations of mines and prospects, but the descriptions are not herein reproduced since they are still available in the Raleigh Report. For the sake of convenience, however, the estimates of tonnage in these three districts are republished without change.

In addition to the republished estimates mentioned above the writer has made an independent study of the coals in Green Sulphur District, Summers County, the results of which are embodied in the text of the following pages. The sections and estimates of this district, combined with the sections and estimates of Krebs and Teets for the three districts previously named, include all the apparent commercial coal of Mercer, Monroe, and Summers Counties, since the portions of the Pottsville that contain valuable beds are entirely eroded from the remaining districts of Mercer and Summers and from all of Monroe County.

Speaking in general terms the Pottsville coals of these four districts are of the soft, smokeless type, being high in fixed carbon and low in volatile matter and also being exceptionally low in ash, sulphur, and phosphorus. Such coals are extensively used for steam purposes, being especially suitable for mechanical stokers and the bunker trade. They also have high favor in the domestic market on account of the practical freedom from smoke, although their physical structure is such that a considerable proportion of slack, which must be used for some other purpose, is accumulated in mining. As coking

coals they are slightly deficient in ash so that the best results are obtained by mixing them with moderately high ash coals from other regions, in order to give more strength to the product, while at the same time their low sulphur and phosphorus content often reduces the percentages of these impurities in the mixture to a permissible figure.

In Mercer County commercial mining is confined entirely to Rock District. According to Krebs the No. 3 Pocahontas has been principally exploited, there being many mines in this seam as well as a few in the No. 6 Pocahontas. In Summers there is only one commercial mine, this being in the No. 6 Pocahontas and situated in Green Sulphur District.

RECORDS OF COAL TEST BORINGS.

In Mercer and Summers Counties, so far as known, no diamond drill holes or other borings for coal have been made on account of the fact that the beds all outcrop in the hills and can be prospected by drifts. In the northern part of Monroe and the southern edge of Greenbrier five holes have been drilled to test the coals of the Pocono Series which have been prospected to a slight extent in the valley of Second Creek near Hokes Mill as already noted in Chapter IX. These five records have been kindly furnished the Survey by Mr. Homer Hoke, of Hamilton, Ohio, who was chiefly interested in the project.

The following hole was drilled on the rim of the plateau formed by the Greenbrier Series, its total depth being 360 feet, but it failed to reach the top of the Pocono, although its base is 80 feet below the surface of the next hole to the northward which was started within the Pocono. The southward plunge along the axis of the Sinks Grove Anticline appears to be responsible for the dip of the strata between the two holes:

Ona Lemons No. 5 Coal Test Boring (5).

Second Creek District, Monroe County; on west side of upland road 0.1 mile north of Spider Den School and 1.6 miles northeast of Sinks Grove; authority, Homer Hoke et al.; completed, June 16, 1922; elevation, 2135′ L.

	Thickness. Feet.	Total. Feet.
Greenbrier Series (250′)		
Clay	20	20
Limestone	230	250
Maccrady Series (110′)		
Lime shale, red	18	268
Shale, red, to bottom	92	360

In the following hole, located one-half mile north of No. 5 (5) the Merrimac Coal horizon appears to have been penetrated at 63-64 feet, its elevation being 1791′ B., as compared to 1760′ B., at **Coal Exposure No. 798 on Map IV** and 1650′ B. at **Coal Prospect No. 797 on Map IV,** both of which are located farther down the northwestern limb of the anticline:

Harry Ellis No. 4 Coal Test Boring (6).

Second Creek District, Monroe County; on short branch of Second Creek 0.7 mile south of Hokes Mill; authority, Homer Hoke et al.; completed, May 25, 1922; elevation, 1855′ B.

	Thickness. Feet.	Total. Feet.
Pocono Series (156′)		
Shale, blue	16	16
Shale, dark and bluish-gray	34	50
Shale, carbonaceous	13	63
Shale, black, with coal seams, **Merrimac Coal?**	1	64
Shale, black	1	65
Shale and sandstone	26	91
Sandstone	14	105
Sandstone and shale, to bottom	51	156

On the evidence of surface outcrops the following hole starts below the level of the Merrimac Coal which should have an elevation of 1750 feet or more at this point, and it probably starts nearly 200 feet below the top of the Pocono Series and therefore must have nearly reached its base, since it is doubtful whether the whole series is much more than 400 feet thick, some of the upper members being locally absent:

A. W. Smith No. 3 Coal Test Boring (7).

Irish Corner District, Greenbrier County; on east side of Second Creek just south of Hokes Mill; authority, Homer Hoke et al.; completed, May 11, 1922; elevation, 1705′ B.

		Thickness. Feet.	Total. Feet.
Pocono Series (216′)			
Clay and boulders		6	6
Sandstone, **Broad Ford?**		45	51
Shale, black, **Sunbury?**		49	100
Shale		35	135
Sandstone ..... 52′ Sandstone and shale... 16 Sandstone, to bottom.. 13	**Berea?**	81	216

In the following record the coal partings found at 160-161 feet and having an elevation of 1734′ B., apparently belong at about the proper level for the Merrimac Coal and indicate its unreliable nature in this vicinity. The heavy sandstone coming just above it is probably the Squaw Oil Sand of the more northwestern counties:

Mary E. Morris Heirs No. 2 Coal Test Boring (8).

Irish Corner District, Greenbrier County; near road fork east of Second Creek and 0.3 mile northeast of Hokes Mill; authority, Homer Hoke et al.; elevation, 1895′ B.

		Thickness. Feet.	Total. Feet.
Sandstone and clay		19	19
Sandstone (water at 60′) .....126′ Sandstone shale, "conglomerated" ..... 2 Sandstone 13	**Squaw Sand**	141	160
Coal partings, **Merrimac?**		1	161
Sandstone		16	177
Sandstone and shale		18	195
Shale		5	200
Shale and sandstone, to bottom		23	223

In the following record the Merrimac Coal horizon appears to belong about the level of the shale at 118-121 feet, the elevation of which is 1659′ B., as compared to 1650′ B. at **Coal Prospect No. 797 on Map IV,** located slightly to the northwest. The black shale at 170-171 feet is plainly too low for the Merrimac Coal since the dip is northwestward, and it evidently belongs at or near the Langhorne horizon:

Hunter Moore No. 1 Coal Test Boring (9).

Irish Corner District, Greenbrier County; along road east of Second Creek and 0.5 mile north of Hokes Mill; authority, Homer Hoke et al.; elevation, 1780′ B.

			Thickness. Feet.	Total. Feet.
Sand and clay			8	8
Sandstone, **Squaw**			107	115
Shale			2	117
Sandstone			1	118
Shale, **Merrimac Coal** horizon?			3	121
Sandstone and shale, laminated			13	134
Sandstone	10′			
Shale	15	**Lindside Sandstone**	36	170
Sandstone, light-gray	4			
Sandstone	7			
Shale, black, "nearly coal,"		**Langhorne Coal?**	1	171
Sandstone, gray, fine-grained	7′			
Sandstone, with layers of shale	24			
Sandstone and shale	86			
Sandstone, dark, close-grained	7	**Broad Ford**	158	329
Sandstone, with quartz partings	21			
Sandstone, badly broken, to bottom	13			

The above borings indicate quite plainly the apparent futility of attempting to find minable coals in the Pocono Series of this region.

MINABLE COALS OF THE NEW RIVER GROUP OF THE POTTSVILLE SERIES.

SEWELL COAL.

Although generally of minable thickness in the southern counties of West Virginia the Sewell Coal does not appear to offer any possibility for exploitation in Mercer and Summers Counties. The statement is made by Krebs (Raleigh Report, page 505) that this coal just caps the top of Bluff Mountain along the Raleigh-Mercer County line and has not been opened, since there is too little cover for mining. He also mentions its absence in the western part of Summers County. In Green Sulphur District, of this latter county, its horizon belongs entirely above the topography.

BECKLEY COAL.

The Beckley Coal which is a valuable seam in some of the southern counties apparently belongs above the topography in all of Summers County. In Mercer it occurs in a few of

the high ridges along the western edge. On pages 539-541 of the Raleigh Report its presence is indicated by Krebs at **Coal Exposures Nos. 458A-458J on Map II,** inclusive, the thicknesses of which vary from a few inches up to five or six feet, there being a considerable amount of slate at most points. Mr. Krebs evidently regards this coal as of little value in Mercer County since he makes no estimate of its tonnage.

FIRE CREEK, "QUINNIMONT," COAL.

In Green Sulphur District, Summers County, the Fire Creek Coal horizon belongs entirely above the topography and this appears to be the case in Jumping Branch District of the same county west of New River since Mr. Krebs records no exposure of the seam in that region. In Rock District, Mercer County, however, he indicates its presence at **Coal Exposures Nos. 520-534 on Map II,** inclusive, as published on pages 561-564 of the Raleigh Report. These openings do not show coal that is thick enough for mining, however, so that no estimate of its tonnage was made by Krebs in this county.

NO. 8 POCAHONTAS COAL.

In Green Sulphur District, Summers County, no exposures of the No. 8 Pocahontas Coal were observed and in Jumping Branch District, of the same county, its presence is not recorded by Krebs, and in Jumping Branch District, Mercer County, he gives no exposures. In Rock District, Mercer County, however, he records its occurrence at **Coal Exposures Nos. 563-574 on Map II,** inclusive, and **Coal Exposures Nos. 599 and 601** on pages 570-573 of the Raleigh Report. On page 573 he estimates that there are fifteen square miles of minable No. 8 Pocahontas Coal in Rock District, with an average thickness of 1′ 6″, making a total of 25,090,560 short tons of coal.

Figure 24, prepared by Mr. Price, shows at a glance the minable areas of No. 8 Pocahontas Coal in Mercer County.

MINABLE COALS OF THE POCAHONTAS GROUP OF THE POTTSVILLE SERIES.

NO. 6 POCAHONTAS COAL.

In Rock District, Mercer County, Mr. Krebs records the presence of No. 6 Pocahontas Coal at **Coal Prospects No. 67 on Map II, No. 600 on Map II, and Nos. 602-611 on Map II,** inclusive, on pages 580-584 of the Raleigh Report. Of these openings Nos. 67 and 611 are commercial mines, analyses of which are published by Krebs on pages 640 and 641 of the Raleigh Report.

In Jumping Branch District, Mercer County, Krebs reports two prospects, **Nos. 612 and 613 on Map II,** as published on page 584 of the Raleigh Report. In Jumping Branch District, Summers County, he apparently found none of this coal since he mentions no prospects and gives no estimate of tonnage.

In Green Sulphur District, Summers County, the No. 6 Pocahontas Coal occurs in the tops of Hump, Wallowhole, and Irish Mountains as indicated by outcrop on Map VI, and as previously described in Chapter VI, page 285. At **Coal Prospect No. 745 on Map VI** located on the southwestern end of Hump Mountain 2.3 miles northeast of New Richmond at elevation 3100′ B., the opening had fallen shut, there being some coal on the dump as recorded in the New Richmond Section, page 242, of this Report.

Farther north along the western side of the same mountain this coal is mined commercially at the following plant:

Hump Mountain Smokeless Coal Company Mine—No. 746 on Map VI.

Green Sulphur District, Summers County; on northwestern slope of Hump Mountain 1.3 miles southwest of Claypool (Humoco P. O.); **No. 6 Pocahontas Coal;** elevation, 3070′ B.

		Ft.	In.
1.	**Sandstone, Pierpont,** massive, pebbly, visible.	50	0
2.	Bone	0	6
3.	**Coal,** soft	3	10
4.	Fire clay shale, gray, pavement	..	..

"Principal office, Mount Hope, W. Va.; daily capacity, 100 tons; 14 miners and 16 laborers employed; electric haulage; greatest rise, east; Andrew G. Thompson, Mine Foreman, authority for mine data; sample (No. 627R) collected from No. 3 of section in No. 1 Main Heading, for composition of which see **Mine No. 746** in the Table of Coal Analyses at the end of this Chapter."

At the above mine the coal is hauled by motor northward along the mountain about one-half mile to the head-house and thence lowered by a gravity plane 4880 feet long to the Sewell Valley Railroad at Claypool (Humoco P. O.), two monitors of 10-tons capacity each being used on the long incline. At the point sampled the coal has a good mining section but in some other parts of the workings it is reported that trouble has been experienced with rolls.

In Wallowhole Mountain no openings were observed in the No. 6 Pocahontas Coal, but the topography is evidently high enough to contain some of this seam, a part of which would be in Fayette and Greenbrier Counties, which corner with Summers on the top of the mountain.

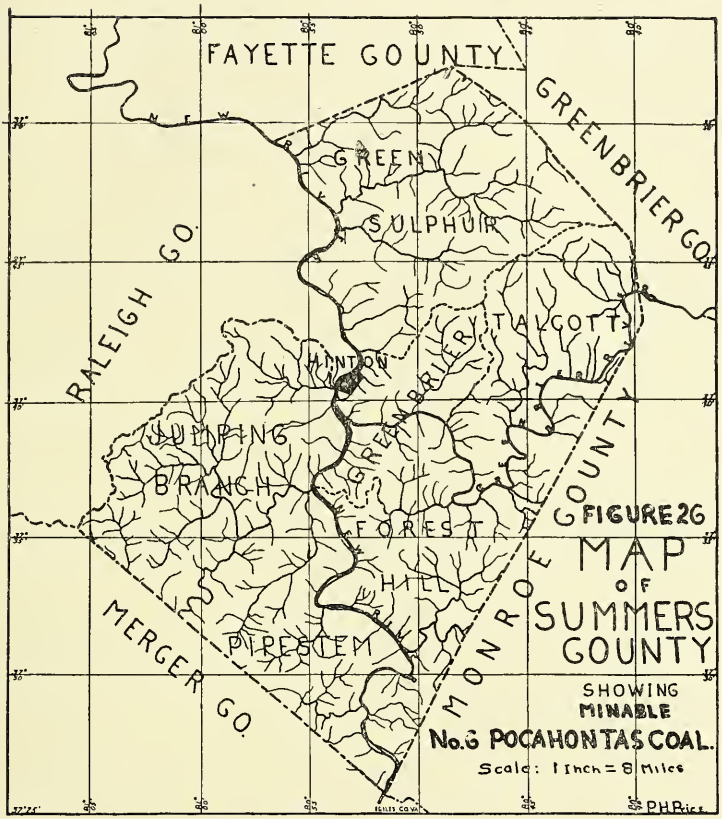
In Irish Mountain, the high part of which is partly in Summers and partly in Greenbrier County, the following opening is recorded by Ray V. Hennen on page 855 of the Fayette County Report of the Survey, the mine and map numbers being changed to harmonize with the present Report:

P. T. Hurley Coal Opening—No. 747 on Map VI.

On Greenbrier-Summers County line, on north slope of Irish Mountain; **No. 6 Pocahontas Coal**; elevation, 3150′ B.; section reported by J. E. Hurley; opening partly closed but examined by Ray V. Hennen:

		Ft.	In.
Coal, soft	0′ 6″		
Bone	0 4		
Coal, soft (slate floor)	3 0	3	10

Figures 25 and 26, prepared by Mr. Price, show at a glance the areas of minable No. 6 Pocahontas Coal in Mercer and Summers Counties, respectively.



Quantity of No. 6 Pocahontas Coal Available.

The following table, computed from planimetric measurements of the outcrops on Maps II and VI, indicates the probable amount of minable No. 6 Pocahontas Coal in Mercer and Summers Counties, the figures for Mercer County being taken from page 585 of the Raleigh Report by Krebs, and those for Summers County being compiled by the writer:

Probable Amount of No. 6 Pocahontas Coal.

Districts	Thickness of Coal. Assumed. Feet.	Square Miles.	Acres.	Cubic Feet of Coal.	Short Tons of Coal.
Mercer County:					
Rock	3	6.0	3,840	501,811,200	20,072,448
Jumping Branch...	2	4.0	2,560	223,027,200	8,921,088
Totals		10.0	6,400	724,838,400	28,993,536
Summers County:					
Green Sulphur.....	3½	0.5	320	48,787,200	1,951,488
Totals for both Counties		10.5	6,720	773,625,600	30,945,024

NO. 3 POCAHONTAS COAL.

The No. 3 Pocahontas Coal, previously described in Chapter VI, page 286, is the most valuable bed of the Pocahontas Group as well as the seam which has mostly been mined in Mercer County. In Rock District, Mercer County, where there are numerous commercial mines and other prospects, it has been described by Krebs on pages 602-621 of the Raleigh Report under **Mines Nos. 68-94,** inclusive, **662-676,** inclusive, and **680-698,** inclusive, the positions of which are indicated on Map II. Analyses of a number of commercial mines of this district are also published on page 641 of the Raleigh Report.

In Jumping Branch District, Mercer County, there are apparently no commercial mines in the No. 3 Pocahontas Coal but in the Raleigh Report, pages 621-623, Mr. Krebs describes **Prospects Nos. 699-705 on Map II,** inclusive.

In Jumping Branch District, Summers County, there are no commercial mines in the No. 3 Pocahontas and Mr. Krebs states that it has been prospected but little, but on pages 623-624 of the Raleigh Report he records its occurrence at **Exposures Nos. 706-709 on Map VI,** inclusive.

In Green Sulphur District, Summers County, the No. 3 Pocahontas Coal has not been mined commercially but it occurs in Hump, Wallowhole, and Irish Mountains, as indicated on Map VI. At **Coal Exposure No. 748 on Map VI,** located on the southwestern slope of Hump Mountain 2.2 miles northward from New Richmond at elevation 2970′ B., the full section of the bed is not exposed, its stratigraphic associations being recorded in the New Richmond Section, page 242. At the northern end of the same mountain it is well exposed at the following prospect:

Hump Mountain Smokeless Coal Company Prospect—No. 749 on Map VI.

Green Sulphur District, Summers County; on the northern end of Hump Mountain 0.9 mile southwest of Claypool (Humoco P. O.); **No. 3 Pocahontas Coal;** elevation, 2950′ B.

				Ft.	In.
1.	Shale, dark, sandy, with plant fossils			7	0
2.	**Coal**			0	3
3.	Shale, dark			4	0
4.	**Coal,** soft, columnar	1′	1″		
5.	Shale, dark	0	7		
6.	**Coal,** soft, columnar	1	3		
7.	Shale, dark	1	1		
8.	**Coal,** soft, columnar	0	11	4	11
9.	Shale pavement			..	..

A sample (No. 628R) was collected from Nos. 4, 6, and 8 of section, the composition of which is published in the Table of Coal Analyses at the end of this Chapter.

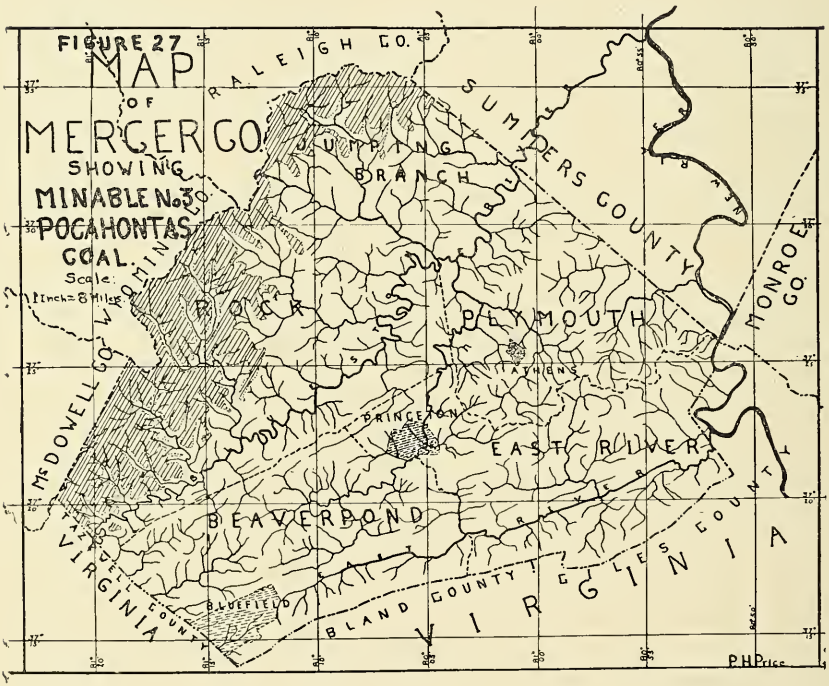
In Wallowhole Mountain no prospects in the No. 3 Pocahontas Coal were observed but on Irish Mountain the following exposure is recorded by Hennen in the Fayette County Report of the Survey, page 864, this outcrop being in the edge of Blue Sulphur District, Greenbrier County:

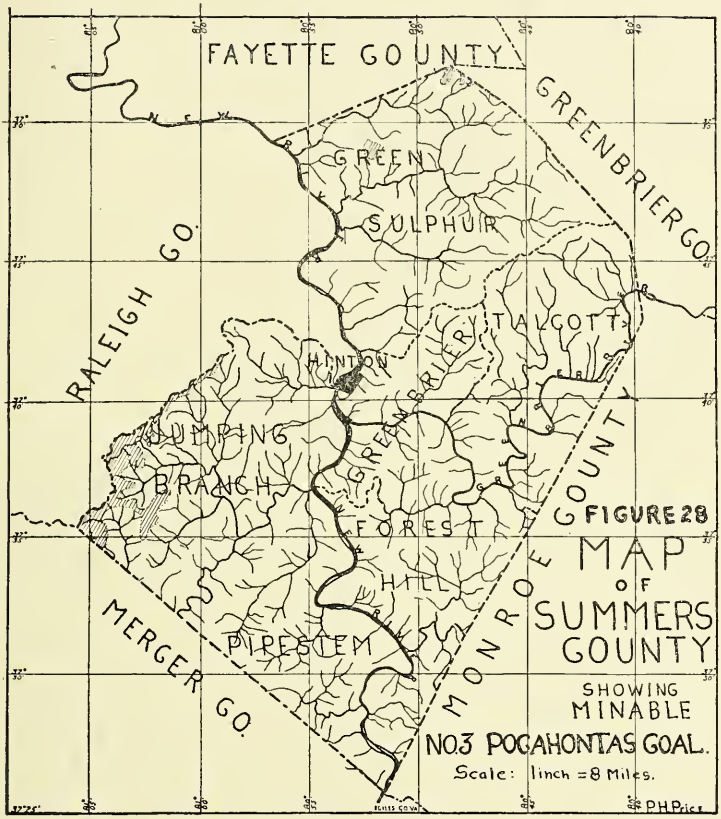
Coal Exposure—No. 750 on Map VI.

In hill road, 1.7 miles S. 30° E. of Springdale, east side of Irish Mountain; **No. 3 Pocahontas Coal**; elevation, 3020′ B.; examined by Ray V. Hennen:

		Ft.	In.
1.	**Coal**, visible, 2′ 0″ to.....	3	0

Figures 27 and 28, prepared by Mr. Price, show at a glance the areas of minable No. 3 Pocahontas Coal in Mercer and Summers Counties, respectively.





Quantity of No. 3 Pocahontas Coal Available.

The following table, computed from planimetric measurements of the outcrops on Maps II and VI, indicates the probable amount of minable No. 3 Pocahontas Coal in Mercer and Summers Counties, the figures used for Mercer being taken from page 625 of the Raleigh Report by Krebs and those for Summers County being compiled by the writer:

Probable Amount of No. 3 Pocahontas Coal.

Districts.	Thickness of Coal Assumed. Feet.	Square Miles.	Acres.	Cubic Feet of Coal.	Short Tons of Coal.
Mercer County:					
Rock	5	48.0	30,720	6,690,816,000	267,632,640
Jumping Branch...	3	12.0	7,680	1,003,622,400	40,144,896
Totals		60.0	38,400	7,694,438,400	307,777,536
Summers County:					
Jumping Branch...	3	4.0	2,560	334,540,800	13,381,632
Green Sulphur.....	3	1.0	640	83,635,200	3,345,408
Totals		5.0	3,200	418,176,000	16,727,040
Totals for both Counties		65.0	41,600	8,112,614,400	324,504,576

NO. 2 POCAHONTAS COAL.

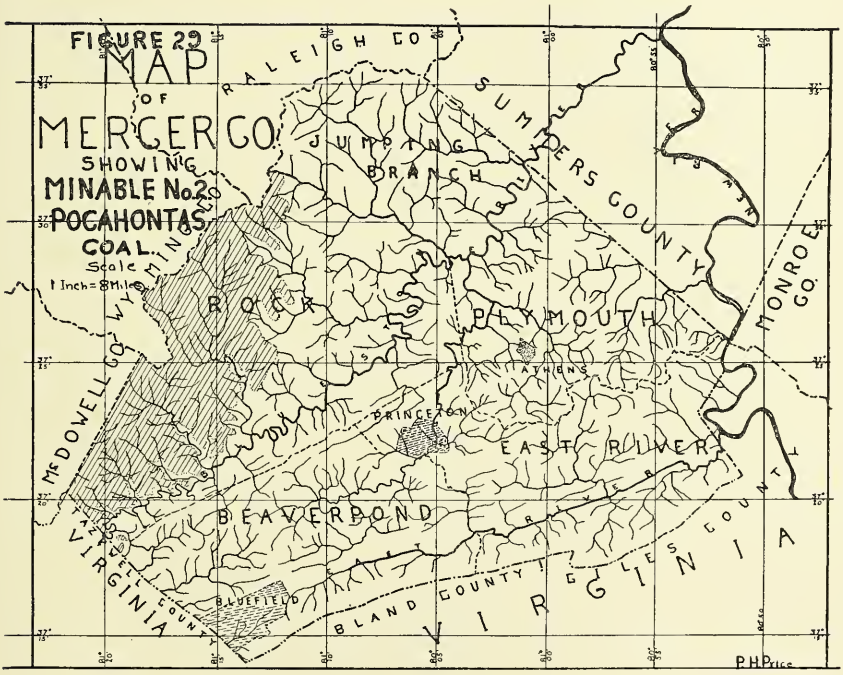
The No. 2 Pocahontas Coal, previously mentioned on page 287, is reported by Krebs as having minable thickness in portions of Rock District, Mercer County, as indicated by his descriptions of **Exposures Nos. 717-734 on Map II,** inclusive, published on pages 628-632 of the Raleigh Report. In this district he assumes a thickness of 2′ 6″ for the coal so that in the estimated 52 square miles (33,280 acres) underlain by the seam there would be 144,967,680 short tons of coal.

In Jumping Branch District, Mercer County, Mr. Krebs makes no estimate of tonnage for the No. 2 Pocahontas Coal, but on page 632 of the Raleigh Report he described **Coal Exposure No. 735 on Map II,** the bed being quite insignificant.

In Jumping Branch District, Summers County, Mr. Krebs makes no estimate of the No. 2 Pocahontas Coal, and he apparently found no prospects in it.

In Green Sulphur District, Summers County, it is not estimated that any No. 2 Pocahontas Coal of appreciable quantity exists.

Figure 29, prepared by Mr. Price, shows at a glance the areas of minable No. 2 Pocahontas Coal in Mercer County.



SUMMARY OF AVAILABLE COAL.

For convenience in reference all the mines, prospects, and exposures described in this Report have been given serial numbers which are printed in blue on Maps II, IV, and VI, these being Nos. 745-802, inclusive. It has already been stated, however, that the principal coal outcrops of both Mer-

cer and Summers Counties have been previously described by Krebs in the Raleigh Report of the Survey where a similar method of numbering was used, ending with number 744. The openings described in that volume in the territory of Mercer and Summers have been repeated on Maps II and VI but the descriptions are not herein republished. It is therefore apparent that the description of any mine or prospect bearing a smaller number than 745 will be found in the Raleigh Report and that the accounts of openings with numbers higher than 744 are contained in the present Report. Disregarding those which refer to coals having no commercial significance in the three counties under study, the following table gives a list of the numbers which refer to the four commercial seams regarded as valuable, as well as a summary of the total amount of coal that each seam is estimated to contain, the estimates for Green Sulphur District, Summers County, being made by the writer and all the remainder by Krebs. In computing tonnage a short ton is assumed as representing 25 cubic feet of coal:

Summary of Available Coal by Counties and Districts (Short tons of 2,000 lbs.).

Coal Bed.	Mines and Prospects on Maps II and VI described Raleigh Report or in Chapter XIII of this Report.	Mercer County.			Summers County.			Total, both Counties.
		Rock District.	Jumping Branch District.	Total.	Jumping Branch District.	Green Sulphur District.	Total.	
No. 8 Pocahontas	563-574.... 599 & 601..	25,090,560	.....	25,090,560	.....	.....	.....	25,090,560
No. 6 Pocahontas	67, 600.... 602-611.... 745-747....	20,072,448	8,921,088	28,993,536	.....	1,951,488	1,951,488	30,945,024
No. 3 Pocahontas	68- 94.... 681-709.... 748-750....	267,632,640	40,144,896	307,777,536	13,381,632	3,345,408	16,727,040	324,504,576
No. 2 Pocahontas	717-735....	144,967,680	.....	144,967,680	.....	.....	.....	144,967,680
Totals	.....	457,763,328	49,065,984	506,829,312	13,381.632	5,296,896	18,678,528	525,507,840

The above table represents the total amount of coal believed to have been available in Mercer and Summers Counties before mining began. From the Reports of the State Department of Mines 66,263,880 long tons (2240 lbs.) of coal were mined in the years 1888-1923, inclusive, or 74,215,544 short tons (2000 lbs.). Making an allowance for the modest amount mined in Mercer County before 1888 and for the additional mining in both counties since 1923 it is evident that about 80,000,000 short tons of coal have now been mined and it is quite probable that 20,000,000 tons more are unrecoverable in old pillars and stumps, leaving the total unmined, or virgin, coal as 425,507,840 short tons. If 80 per cent. of this can be eventually recovered there is still left in the two counties a total of 340,406,272 short tons.

MINABLE COALS BY MAGISTERIAL DISTRICTS.

The minable coals of the three counties, as so classified in this and the Raleigh Report, have been described by magisterial districts. For these coals in Rock and Jumping Branch Districts, Mercer County, and Jumping Branch District, Summers County, an item of "Minable Coals by Magisterial Districts" will be found in the Index of the Raleigh Report, and for the same data in reference to Green Sulphur District, Summers County, a similar item is published in the Index of this Report, making this information available without further discussion.

TABLE OF COAL ANALYSES.

The following brief table, containing the proximate analyses of eight mines and prospects and the ultimate analyses of two of these, has been prepared entirely by members of the Survey Staff. All samples were taken in the field by the writer and were then analyzed in the laboratory of the Survey by B. B. Kaplan, Chemist. The samples of Pocahontas Coal come from Green Sulphur District, Summers County, and are therefore few in number. Numerous samples, however, of the Pocahontas Coals in Rock and Jumping Branch Districts,

Mercer County, and Jumping Branch District, Summers County, but principally from the commercial mines in the first of these three districts, secured in earlier years by C. E. Krebs and D. D. Teets, Jr., both former members of the West Virginia Geological Survey, and various other samples by the U. S. Geological Survey and the U. S. Bureau of Mines, have been previously published in the Raleigh Report of the Survey, pages 638-648, the mine numbers being the same as those engraved on Maps II and VI of the present Report.

In the table below, the numbers on the left-hand margin correspond to the numbers given with the descriptions of the mines, prospects, or exposures and with the symbols on Maps II, IV, and VI. In taking the samples, bands of slate or shale which would be rejected in actual mining were not included. In the case of **Prospect No. 795** an additional sample was taken from a smutty or oxidized band in one of the Pocono coals:

Table of Coal Analyses.

(All samples analyzed on "as received" basis.)

No. on Map II, IV, or VI.	MINE, PROSPECT, OR EXPOSURE.	Coal Bed.	PROXIMATE.				COMMON TO BOTH		ULTIMATE.				Calorimeter B. T. U. for 1 lb. of Coal.	Calculated B. T. U. for 1 lb. of Coal.	Fuel Ratio (Carbon Divided by Oxygen+Ash).	Carbon Ratio (Fixed Carbon Divided by Sum of F. C. and V. M.)
			Moisture.	Volatile Matter.	Fixed Carbon.	Phosphorus.	Ash.	Sulphur.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.				
746	Hump Mt. Smokeless Coal Co.	No. 6 Pocahontas..	0.78	18.22	73.70	0.0182	7.30	0.69	83.17	4.45	3.21	1.18	14,419	14,500	7.01	80.18
749	Hump Mt. Smokeless Coal Co.	No. 3 Pocahontas..	1.20	18.22	67.16	0.0939	13.42	0.67	73.52	3.95	7.27	1.17	12,752	12,692	3.25	78.66
778	B. E. Kirtner.....	Raines Corner.....	7.35	24.37	26.98	.....	41.30	0.263	....	....	....	....	.....	.....	....	52.54
794	Clarence Symms.....	Merrimac	3.05	10.45	63.91	.....	22.59	0.025	....	....	....	....	.....	.....	....	85.95
795	Thomas Long.....	Merrimac (a).....	1.49	11.31	56.12	.....	31.08	0.38	....	....	....	....	.....	.....	....	83.23
795	Thomas Long.....	Merrimac (b).....	6.12	17.48	62.77	.....	13.63	0.45	....	....	....	....	.....	.....	....	78.22
796	Ernest Fleshman.....	Merrimac	0.56	7.30	17.21	.....	74.93	3.68	....	....	....	....	.....	.....	....	70.22
797	Mattie Abbott.....	Merrimac	2.27	9.91	12.82	.....	75.00	0.087	....	....	....	....	.....	.....	....	56.40
801	Public road.....	Merrimac	14.40	29.30	23.57	.....	32.73	0.135	....	....	....	....	.....	.....	....	44.58
	Average (c).....	Merrimac	4.35	13.65	34.72	.....	47.27	0.86	....	....	....	....	.....	.....	....	68.08

a. Sample from main bench of coal.
b. Sample from smut band.
c. Excluding sample of smut band at Prospect No. 795.

TABLE OF SOFTENING TEMPERATURES AND ANALYSES OF COAL ASH.

In the following brief table will be found a determination of the softening temperatures of the ash of the two Pocahontas Coal samples secured in Green Sulphur District, Summers County, these determinations having been made by Mr. Kaplan in the laboratory of the Survey at Morgantown. Owing to the refractory nature of the ash in these coals it has been possible to obtain only the incipient fusion, or softening, temperatures. The melting points would presumably be considerably higher:

Table of Softening Temperaures and Analyses of Coal Ash.

	Mine No. 746 on Map VI.	Prospect No. 749 on Map VI.
Softening temperature of ash.....	2735° F	2735° F.
Ash Analysis:		
	Per cent.	Per cent.
Silica (SiO_2).....	57.40	49.54
Alumina (Al_2O_3).....	27.79	34.54
Iron (Fe_2O_3).....	8.12	9.90
Titanium (TiO_2).....	2.01	0.56
Lime (CaO).....	1.20	1.85
Magnesia (MgO).....	0.18	0.05
Sodium (Na_2O).....	1.22	0.56
Potassium (K_2O).....	1.31	0.64
Phosphoric Acid (P_2O_5)..	0.25	0.70
Sulphuric Acid (SO_3)....	1.05	1.75
Totals	100.55	99.99

Page References to Detailed Descriptions and Sections of Coal Mines listed in Preceding Tables.

No. on Map II, IV, or VI.	Sample No.	Coal Bed and Name of Owner.	Location.	Page.
		No. 6 Pocahontas:		
746	627R	Hump Mt. Smokeless Coal Co.....	1.3 mi. S.W. of Claypool (Humoco P. O.)	675
		No. 3 Pocahontas:		
749	628R	Hump Mt. Smokeless Coal Co.....	0.9 mi. S.W. of Claypool (Humoco P. O.)	679
		Raines Corner:		
778	634R	B. E. Kirtner.....	0.4 mi. N. E. of Ada.	410
		Merrimac:		
794	617R	Clarence Symms.....	1 mi. S. E. of Brick Church	515
795	614R	Thomas Long.....	0.9 mi. S.W. of Lindside	515
795	615R	Thomas Long.....	0.9 mi. S.W. of Lindside	515
796	629R	Ernest Fleshman.....	0.6 mi. S. E. of Lindside	218
797	626R	Mattie Abbott.....	0.7 mi. North of Hokes Mill.....	516
801	609R	Public road.....	0.5 mi. North of Pedro	518

CHAPTER XIV.

LIMESTONE.

GENERAL STATEMENT.

The limestone resources of Mercer, Monroe, and Summers Counties are so large and important from an economic viewpoint that it seems advisable to assemble the essential data in one Chapter where they may be available in concise form, either by reference or direct description. In conformity with that idea previous Chapters on Stratigraphy give full descriptions of only those minor calcareous horizons which have little or no commercial significance. Next to the coal of the western edges of Mercer and Summers Counties, which is of superior quality but of limited extent, limestone is probably the most valuable natural commodity that the three counties can now offer to the markets of the country. They originally contained six principal items of natural wealth, the same being their timber, coal, limestone, agricultural soils, water-power resources, and iron ore. Of these the timber has been almost entirely removed, leaving many long ridges where reproduction will be slow. The coals are being exploited on a large scale and already have been about one-fifth exhausted. Except in the central belt of Monroe County and a limited portion of Mercer, where conditions are especially favorable, the agricultural possibilities are extremely limited by a steep and often boulder-strewn topography which precludes the idea of much cultivation, as has been made evident by heavily washed slopes in many of the valleys. The original wealth of limestone, however, remains practically untouched, only a few thousand tons having been quarried. The same statement is

true about iron ore except that the deposits suffer severely in comparison with the richer and more abundant ranges of the Great Lakes region and offer no present hope of extensive exploitation. The water-power resources are still available, only a small fraction having been developed, but any hydroelectric project in the territory naturally competes with comparatively low cost steam plants that burn cheap coal so that efforts toward the utilization of the rivers have not yet been successful.

It is thus apparent that limestone is the most hopeful mineral or natural commodity, next after coal, and will perhaps eventually displace it as an economic resource in the three counties. The deposits are located where they may be quarried to great advantage and there is trunk-line transportation on which the product may be loaded or to which it may be hauled by easily constructed spurs at many points.

The quality of the various limestone beds indicates that material is available from which there may be manufactured Portland cement, agricultural and building lime, railroad ballast, road material, concrete aggregate, and many other items, including the production of stone for blast-furnace flux and for the manufacture of steel, paper, glass, and leather. In quantity there are so many billions of tons that the supply may be regarded as inexhaustible.

Figures 12, 13, and 14, pages 456-458, indicate the principal areas of pure limestone in the three counties. In compiling these figures no attempt is made to indicate all the limestone in each county but rather the formations which offer the most abundant and easily quarried supplies of reasonably good stone. Figure 12, for Mercer County, shows the Greenbrier and Stones River, both of which pass across the county, but does not show the Avis Limestone of the Mauch Chunk Series which outcrops in the vicinity of Athens and at other points on either flank of the Abbs Valley Anticline. As will be later detailed this limestone has a local value in the county but suffers by comparison with the Greenbrier and Stones River and will probably have little commercial exploitation. Its position at any point may be determined from the green

structure contours on Map II which are based on its horizon.

Figure 13, for Monroe County, indicates the Greenbrier and Stones River, both of which outcrop in abundance, but the Avis is found in only a small part of the Hurricane Ridge Syncline and scarcely has even local importance. The Trenton Limestone, belonging in the lower part of the Martinsburg Series, has some very good possibilities as a cement stone in Monroe County but is not shown on the figure since it occurs on the same slopes and only a few hundred feet above the Stones River.

Figure 14, for Summers County, indicates the Avis Limestone, which makes an abundant outcrop in the county, and also the Greenbrier, the areal extent of which is limited to a few localities along Greenbrier River. In this county it is apparent that the Avis is the more important bed on account of its availability over so much more territory.

The dolomites of Mercer and Monroe Counties are not indicated on the figures because they do not fall within the definition of pure limestones. These will be considered in the present Chapter, however, and their outcrops are shown on Maps II and IV.

The use of local limestone in the three counties has been largely confined to road material, concrete aggregate, agricultural lime, and the manufacture of concrete blocks. So far as known no attempt has been made to build masonry structures of limestone, since there are few, if any, beds that are well adapted to this purpose, although there are occasional oolites in the Greenbrier Series.

LIMESTONES OF THE MISSISSIPPIAN PERIOD.

In the Mississippian Period there are many limestones of diverse character. In the Mauch Chunk Series, with certain important exceptions, they are generally thin, siliceous, and impure. In the Greenbrier Series they are abundant, comprising most of its bulk and including some very good stone. In the Maccrady Series the few limestones found are shaly and impure and in the Pocono Series they are almost totally

absent. The following table indicates, in descending order, the calcareous beds of the period that deserve economic discussion:

Mauch Chunk Series—Hinton Group:
- Avis Limestone

Mauch Chunk Series—Bluefield Group:
- Raines Corner
- Reynolds
- Glenray

Greenbrier Series:
- Alderson
- Union
- Pickaway
- Taggard
- Patton
- Sinks Grove
- Hillsdale.

LIMESTONES OF THE MAUCH CHUNK SERIES.

AVIS LIMESTONE.

The Avis Limestone, previously described on pages 347-351, and used as the key rock of the green structure contours on Maps II, IV, and VI, is the youngest and therefore the highest calcareous formation with economic possibilities in the three counties. It is generally composed of two hard benches of good limestone separated by a shaly middle portion, the total thickness varying from 20 to 40 feet.

In Mercer County it has been quarried at several points along the flanks of the Abbs Valley Anticline. On a branch of North Fork of Brush Creek 0.5 mile northwest of Bratton School and 2.2 miles northeast of Littlesburg there is a quarry at elevation 2480′ B., showing 20 feet of steel-gray, somewhat shaly, and fossiliferous limestone, dipping southward at the rate of 10 degrees and having been used mostly for local road material.

On the east side of Laurel Creek 1.2 miles eastward from Athens a considerable quarry has been operated for general purposes, there being 25 feet of stone visible, with the base of the quarry at elevation 2290′ B. coming only a few feet above creek level.

On Tracy Fork of Laurel Creek, just east of Martin School and 1.1 miles southwest of Pettry, 10 feet of the upper portion of the bed has been quarried at elevation 2335′ B., the exposed face representing only about one-fourth of the total formation.

On the ridge road between Hackett and Island Creeks and 0.9 mile northeast of Pettry, it is well exposed at elevation 2410′ B., being steel-gray and mostly hard, with a few shaly streaks and having a thickness of 35 feet and a dip toward the north. This outcrop has not been quarried.

In Monroe County its horizon is found only in a limited portion of the Hurricane Ridge Syncline; and there it does not appear to be of sufficient thickness and purity to be of economic value.

In Summers County it outcrops in the valley walls of New River and many of its tributaries, being usually about 40 feet thick with a shaly streak near the middle. On account of the fact that no other limestone is readily available it here assumes an importance that it does not have in the region farther south, since it can be quarried both for agricultural lime and for construction purposes including road material.

On the road descending the northern end of Big Swell Mountain 0.8 mile southward from Green Sulphur Springs it is visible at elevation 2025′ B., being 35 feet thick and shaly.

On the road descending Chestnut Mountain toward Laurel Creek one mile southeast of Ramp it is exposed at elevation 2240′ B., being somewhat shaly and having a thickness of 25 feet.

On the mountain road 1.1 miles west of Clayton it is 20 feet thick, steel-gray, and fairly hard, at elevation 2525′ B.

At the **B. K. Litsinger Exposure** on the road ascending Keeney Mountain one mile southeast of Hinton, the Avis outcrops at elevation 2065′ B., being steel-gray, somewhat shaly, and 40 feet thick. Here a sample (No. 632R) was collected from the firmer portions, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

On the road ascending Wolf Creek Mountain at **Fossil Lot 198 on Map VI,** 0.9 mile southeast of Bellepoint, it is 45

feet thick, partly gray and hard and partly yellow and shaly at elevation 2040′ B.

At the eastern end of Wolf Creek Mountain it is visible in the public road at elevation 2380′ B., having a thickness of 40 feet and a gray color.

Farther south on the same mountain just south of Low Gap School 1.2 miles east of Bertha, it is exposed at elevation 2395′ L., being massive at the top but shaly at the base, with a total thickness of 40 feet.

At the extreme southern end of Wolf Creek Mountain 2.7 miles northeast of Warford it outcrops at elevation 2420′ B. in the public road, being 30 feet thick and steel-gray but somewhat shaly.

At the **Wiley McGraw Exposure**, on the Tallery Mountain road 1.4 miles south of True, the following succession is visible:

		Feet.
1.	Limestone, shaly	5
2.	Limestone, steel-gray, hard	15
3.	Limestone, very shaly	10
4.	Limestone, steel-gray, hard	10
	Total	40

A sample (No. 630R) was collected from Nos. 2 and 4 of section, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

RAINES CORNER LIMESTONE.

The **Raines Corner Limestone** of the Bluefield Group, previously described on pages 404-409, is a dark and slightly carbonaceous but quite hard and durable ledge, its thickness varying from 5 to 10 feet. In the western part of Monroe County and in southeastern Summers there are many exposures of this limestone in localities where no other calcareous stratum is readily available and where it could therefore be used locally to good advantage in building concrete or surfacing roads. These exposures have been described at length in the reference above made.

REYNOLDS LIMESTONE.

The **Reynolds Limestone** of the Bluefield Group, described on pages 426-430, is a gray and generally shaly deposit, usually only 10 to 15 feet thick but occasionally becoming firmer and thicker, its maximum being about 50 feet. It is not apparent that this bed could be used independently to much advantage, except at infrequent occurrences, but if quarried in conjunction with the Ada Shale which is the next higher formation it might become a valuable mixing agent to reduce the high lime content of some of the pure beds of the Greenbrier Series in case these latter should be used in the manufacture of Portland cement. Outcrops of the Reynolds Limestone have been described at length in the reference above cited.

GLENRAY LIMESTONE.

The **Glenray Limestone** of the Bluefield Group, described on pages 432-437, is a heavy deposit, often 80 to 125 feet thick and frequently quite massive and hard, but sometimes shaly or sandy. It is not well developed in Mercer but at many localities in Monroe and the eastern edge of Summers County it could be quarried to advantage for road material or for concrete aggregate. Its chemical qualities have not been investigated but judging from its appearance it would have a considerable percentage of silica. Its outcrops have been described at length in the above reference.

LIMESTONES OF THE GREENBRIER SERIES.

The Greenbrier Series, varying in thickness from about 700 feet in northern Summers County, as recorded in well records, to about 1,800 feet at exposures in southern Mercer County near Bluefield, and composed almost entirely of limestones that have many diverse characteristics, offers almost unlimited opportunities for commercial exploitation in the three counties. As indicated by Figures 12, 13, and 14, pages 456-458, and more in detail by Maps II, IV, and VI, there is a vast outcrop of this series in Mercer and Monroe Counties

but more extensive in the latter, as well as a more restricted area in Summers. In Chapter VIII it has already been pointed out that the members of this series differ so widely in certain physical features that they can usually be traced by these differences without the aid of laborious paleontologic studies, although the latter make an important check on precise correlations. To mining engineers and others who are frequently confronted with a baffling similarity of appearance in limestone beds which may be wholly unlike in chemical character and which must therefore be distinguished by some other means, the radical differences in the appearance of the Greenbrier members will appeal as a factor of prime importance.

In chemical composition the limestones of the Greenbrier appear to vary from 2 to 40 per cent. in silica, from 50 to 95 per cent. in calcium carbonate, while the magnesium carbonate is usually only one or two per cent., although it is much higher in some cases, the maximum noted being 20 per cent. Limestones of such character would not in general be adapted for blast-furnace flux or for certain other purposes where extremely low silica is required but many of the analyses fall within the range demanded for the manufacture of Portland cement where a calcium carbonate content of 65 to 75 per cent. is favored and a magnesium carbonate content of less than five per cent. is required. It thus appears that at various localities some of the members of the Greenbrier are eminently suited for Portland cement and could be used without the admixture of much other material. At many other points it might be necessary to add shale in order to reduce the lime content, but this material is nearly always available in the basal part of the Mauch Chunk Series just above the Greenbrier. In Preston County the Greenbrier has been used for many years in the manufacture of Portland cement and in some of the southern Appalachian States a limestone of the same age is used for this purpose.

Direct rail transportation is afforded for many miles of the Greenbrier deposits in all three counties and there is an abundant supply of water and labor while vast quantities of

high-volatile coal are available in counties lying to the westward and traversed by the three trunk-line railroads which pass through the Greenbrier outcrops. With all these favorable factors it does not appear that a more logical region for the development of a cement industry could readily be found.

In physical character the limestones of the Greenbrier are quite generally hard and durable, with a few exceptions, and are therefore suited for use as road material, and for concrete aggregate in structures where fireproofing is not required. There is one bed of oolite that has a proper structure for building stone but this member is too thin for commercial exploitation. Some of the other limestones are weakly oolitic but all have the irregular fracture of a dense limestone and would not be regarded with favor by the quarrying industry.

ALDERSON LIMESTONE.

The **Alderson Limestone,** coming at the top of the Greenbrier Series, and already described on pages 462-466, is a dark-gray or yellowish deposit composed of alternating beds of hard and siliceous material, pure and granular limestone, and shaly calcareous zones, with a thickness varying from 75 to 325 feet. Some of its strata could be used to advantage where a firm broken stone is required while others would be of little value. Its content of calcium carbonate is generally too low for independent use as a limestone but taken in conjunction with the pure Union Limestone just below it an advantageous mixture for Portland cement would be possible in many localities.

In Mercer County a sample (No. 641R) was collected from this limestone at the **W. H. Preston Exposure** on East River one-half mile northwest of Wills Station, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. The details of this exposure will be further discussed in connection with the Union Limestone on a later page where it is desirable to present all the data on this locality.

The **Lewis McNeer Limestone Quarry,** located in Monroe

County on the south side of Indian Creek just opposite Gin Hollow and near Salt Sulphur Springs and marked by **Fossil Lot 155 on Map IV,** has worked the lower 30 feet of a 50- to 60-foot stratum of blue, shaly limestone coming within the Alderson member, the elevation of the base of the quarry being 1805′ B. A limited amount of stone from this quarry has been used for local road construction but the material has the appearance of being entirely too shaly for such a purpose.

No other quarries in the Alderson Limestone were observed in the three counties but the principal outcrops have already been described in the above reference.

UNION LIMESTONE.

The **Union Limestone,** previously described on pages 467-472, is a massive stratum of hard, pure limestone, easily recognized by its grayish-white color in contrast to the darker material both above and below it and also by its occasionally oolitic structure and marine fauna in which **Pentremites** are usually abundant. With a thickness of 100 to 275 feet this member offers almost unlimited possibilities for exploitation in Mercer and Monroe Counties, most, if not all, of its bulk being below drainage in Summers.

The **McDowell County Stone Quarry,** owned by McDowell County but operated under lease to **B. K. Newell & Company,** is located in Mercer County on the north side of Bluestone River, along the Norfolk & Western Railway, just west of Nemours village and nearly on the axis of the Abbs Valley Anticline. The present quarry face is 500 feet long and 75 feet in height, extending 100 feet into the hill, while slightly westward there is an older quarry which is now abandoned, the total exposure of beds being about 265 feet, since there is a southeastward dip of 30 degrees. Most of the stone is hard and durable, being partly gray, partly yellow, and partly blue or dark. The product is crushed at a stationary plant in the quarry, loaded into railroad cars, and transported to McDowell County for road material. As indicated by the section published on pages 471-472, the upper 165 feet, com-

prising the new quarry, appear to be in the Union Limestone while the lower 75 feet belong to the Pickaway, there being an intermediate zone of material covered by debris in the bottom of the new quarry. A sample (No. 595R) was collected from Nos. 4-8, inclusive, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. The lime content is low, there being much silica and magnesium.

The **Crollins Stone Company Limestone Quarry,** located in the eastern edge of Bluefield, Mercer County, just north of the Norfolk & Western Railway and just west of the Bluefield-Princeton road, and 1.6 miles east of Bluefield Station, operates in the Union Limestone, the base of the quarry having an elevation of 2490′ B. and its dimensions being about 100 feet long by 100 feet into the hill and 50 feet high. The stone is dark-gray and hard but mostly quite pure, being cavernous and having a few geode holes in which there is some trapped crude oil, and there being occasional nodules of black chert. At this locality the strata are overturned, the present dip being southward at the rate of 66 degrees. According to W. M. Tilson, Superintendent, the plant puts out about 30 cubic yards of stone daily, used partly for concrete aggregate and partly for ballast. A small concrete block plant, utilizing some of the screenings, is separately operated by Floyd Henderson at the quarry site. A sample (No. 593R) was collected across the exposed beds, comprising nearly 100 feet of strata, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

The **Charles Kidd Quarry,** now inactive, was located along and north of the Bluefield-Princeton road 0.7 mile southwest of Stony Gap and about 500 feet west of Crusher Station on the trolley line at elevation 2440′ B. Here the limestone is overturned and now dipping southward at the rate of 65 degrees, about 50 feet of strata having been worked along a face of 150 feet. The stone is gray and hard, with a few softer streaks and with a little black chert, and appears to be part of the Union Limestone. The product was reported to have been crushed for ballast along the trolley line and may

also have been used in surfacing the highway.

At the mouth of a ravine, 0.4 mile due south of Stony Gap, the upper 50 feet of Union Limestone was once quarried in an old operation which has now been abandoned, its location being just north of the Norfolk & Western Railway and approximately the same as **Fossil Lot 116 on Map II.** Here the stone is dark and hard, weathering yellow, its stratigraphic associations and other particulars being noted in the Stony Gap Section, page 199.

Farther east in the valley of East River a very good exposure of the Alderson and Union Limestones is afforded where the river cuts through a narrow ridge just northwest of Wills Station and southwest of Hales Gap Tunnel. Starting just south of the Virginian Railway at the northern end of this exposure and traversing southeastward along the east side of East River, and continuing to the point where the railroad first bends eastward along the strike 0.3 mile northwest of Wills Station, the following measurement was made by Mr. Price and the writer along the upturned edges of these beds, the strata being overturned and now dipping southeastward at the rate of 40 to 50 degrees:

W. H. Preston Limestone Exposure.

		Thickness. Feet.	Total. Feet.
Mauch Chunk Series—Bluefield Group (....)			
1. **Shale, Lillydale,** black, fissile, exposed in Hales Gap, not measured		...	...
Greenbrier Series (425′)			
2. **Limestone, Alderson,** dark, siliceous **(Sample No. 641R)**		295	295
3. **Limestone,** gray, hard, pure, mostly granular **(Sample No. 640R)**	60′		
4. **Limestone,** gray, hard, with numerous marine fossils, brachiopods, crinoids, blastoids **(Pentremites),** bryozoa, etc. **(Sample No. 639R)**	60	**Union Limestone**	130	425
5. **Limestone,** dark-gray, slightly oolitic and streaked with calcite **(Sample No. 638R)**	10		

At the above exposure the whole thickness of the Alderson Limestone is recorded but probably not more than one-half of the Union Limestone is included in the 130 feet of its measured beds, the lower portion being too poorly exposed to permit of measurement. A sample (No. 641R) was collected across the face of the Alderson Limestone, No. 2 of section; another sample (No. 640R) was collected from the upper 60 feet of the Union Limestone, No. 3 of section; another (No. 639R) from the next lower 60 feet of this member, No. 4 of section; and another (No. 638R) from the 10 feet of oolite recorded at the bottom of the measured section and occurring in the cut of the Norfolk and Western Railway slightly east of the bridge across East River. The compositions of all four samples will be found in the Table of Limestone Analyses at the end of this Chapter. The analyses show that the Alderson Limestone is high in silica and low in calcium carbonate and also low in magnesium carbonate, and that the Union Limestone ranges from 62 to 91 per cent. in calcium carbonate but is uniformly quite low in magnesium carbonate.

Just north of the ridge made by these limestones there is a long exposure of the Lillydale Shale, basal member of the Mauch Chunk Series, which is there about 100 feet thick. A sample (No. 636R) of this shale was collected from the heavy fill of the Virginian Railway east of Hales Gap Tunnel, as already published on page 442. This shale contains 21 per cent. of alumina, making it apparent that its admixture with properly quarried proportions of the Alderson and Union limestones would produce an ideal assemblage of materials for Portland cement. Other conditions favorable for the location of a cement mill at this point are equally good. Northeast of the measured section the limestones make a continuous ridge about 1½ miles long and southwestward they make a similar ridge for several miles. The main lines of both the Norfolk & Western and Virginian Railways pass the locality and both carry abundant quantities of high-volatile coal from the neighboring counties to the westward. Water is afforded by East River; and at Glenlyn, Virginia, only two miles northeastward, is located one of the large power-plants

of the Appalachian Power Company. Labor conditions would appear to be very good, since there are few large industrial plants in this community.

The **Otto Williams Limestone Quarry,** located in Monroe County on the east side of Rich Creek 0.5 mile southeast of Brick Church and 2.7 miles southwest of Lindside with an elevation of 1860′ B., appears to belong in the Union Limestone although the stratigraphic evidence is, somewhat obscure. Here there is an outcrop of 50 feet of gray, hard limestone, with streaks of oolite, now overturned and dipping southward at an angle of 40 degrees. A small amount of this exposure has been quarried and burned for agricultural lime to serve local needs. A sample (No. 620R) was collected across the face of the outcrop, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

In the vicinity of Union, Monroe County, along the Hurricane Ridge Syncline, there is a vast amount of outcropping Union Limestone and it also makes a long outcrop around the eastern, northern, and western sides of the Swoopes Knobs plateau where it has been raised to a high level by the Sinks Grove Anticline, as previously described in Chapter VIII. No samples were secured at these exposures.

At the **Frank Matty Limestone Exposure,** along the public road north of Indian Creek 0.9 mile east of Greenville, Monroe County, and one-half mile east of the Abbs Valley Anticline, there is a 50-foot reef of hard, bluish-gray limestone at elevation 1635′ B., dipping southeastward at the rate of 5 degrees and containing many marine fossils among which **Archimedes** and **Pentremites** were noted. With the attendant stratigraphic evidence there is little doubt that this exposure is part of the Union Limestone. A sample (No. 621R) was collected across the outcrop, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. The deposit contains 91 per cent. of calcium carbonate and only a small amount of magnesium carbonate.

At the **Dr. J. C. Hughes Heirs Limestone Exposure,** located west of the Abbs Valley Anticline slightly east of Wolf Creek 0.5 mile west of Ash Hill School and 1.3 miles

southwest of Johnson Crossroads at elevation 1770′ B., there is an outcrop of 100 feet of hard, blue limestone containing a little black chert but being very pure at the base and also having brachiopods and blastoids **(Pentremites),** with ample additional evidence to correlate it with the Union Limestone. A sample (No. 622R) was collected from the basal 20 feet of this exposure, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. It shows a good grade of stone with little magnesium carbonate. On account of the rapid northwestern dip at this exposure the elevation of the sample secured is 1835′ B., or 65 feet higher than the western edge of the reef.

At the **Johnson and George Limestone Exposure** along an upland road 0.4 mile southwest of Johnson Crossroads, the same stratum of Union Limestone, with **Pentremites** and numerous other fossils, is visible at elevation 2005′ B., the thickness being unknown. A sample (No. 623R) was collected at this point, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. This is the purest sample obtained from the whole Greenbrier Series, the silica being only 2.10 per cent., while the calcium carbonate is 96.80 per cent.

At the **C. M. Hinkle Limestone Exposure,** located on the head of a branch of Broad Run 2.1 miles westward from Sinks Grove and 0.8 mile southwest of Sugar Tree School, there is a visible outcrop of 100 feet of Union Limestone at elevation 2100′ B., with a rapid westward dip toward the Knobs Syncline. The stone is hard, gray, and pure with streaks of oolite and with many marine fossils among which **Pentremites** were noted, and with other evidence that it belongs to the Union horizon. A sample (No. 624R) was collected across the outcrop, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

In Summers County the Union Limestone was not observed above drainage but it is possible that its extreme upper portion might be exposed at one or two points along the Alderson Anticline between Lowell and Wolf Creek Station.

PICKAWAY LIMESTONE.

The **Pickaway Limestone,** as previously described on pages 473-476, is a very dark, hard, and usually sandy stratum varying in thickness from 175 to 400 feet. As already noted it can usually be identified in the local area by its peculiar stylolitic structure, the development of vertical cleavage being well advanced. On account of its siliceous nature and its considerable content of magnesium carbonate, it is not apparent that this limestone would generally be as suitable for Portland cement as some other beds of the Greenbrier, although there may be exceptions to this rule; and it is also improbable that it would be much good as agricultural lime, since there is too much inert matter. It is very hard and durable, however, and makes good material for concrete aggregate or road surfaces, having been used quite extensively for the latter purpose near its type locality in Monroe County.

The **Baker Stone Company Limestone Quarry,** located in Mercer County in the eastern edge of Bluefield 1.3 miles east of the station and slightly north of the Norfolk and Western Railway at elevation 2475′ B., apparently belongs to the Pickaway member although the evidence is not conclusive. Here it is overturned, the present dip being southward at an angle of 58 degrees. The quarry has been worked westward about 150 feet against the butts of the stone and across strata 100 feet thick with a height of 80 feet, the stone being hard and blue with no chert. According to S. R. Bowers, Foreman, the plant puts out about 900 cubic yards of crushed stone per month, used for concrete aggregate and road purposes, a No. 4½ Champion Crusher being utilized. A sample (No. 594R) was collected across the quarry face, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

At the **Ward Bailey Limestone Quarry,** located in a ravine south of East River slightly east of the Bluefield water pump station and 0.5 mile south of Stony Gap, the upper 75 feet of the Pickaway Limestone has been quarried just south of the Norfolk and Western Railway, but the place was long

ago abandoned. Here, as noted in the Stony Gap Section, page 199, the stone is blue, with 10 feet of calcareous sandstone at the top and with a little black nodular chert at the base, the entire stratum being more than 400 feet thick. According to report the material quarried from the upper part was mostly used for ballast and construction purposes. A sample (No. 592R) was collected from the limestone in the quarry, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

Other exposures of the Pickaway Limestone may be noted in eastern Mercer County but so far as observed there are no other quarries.

In Monroe County this limestone has been quarried at several points. At the **Mrs. George Davidson Limestone Quarry,** located along the Union-Willow Bend road 1.3 miles south of Union and on the first ridge north of Burnside Branch at elevation 2110′ B., this stone has been used for local road material, being dark and hard, with incrustations of black, carbonaceous matter on the cleavage-planes. A sample (No. 596R) was collected from the quarry reef, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

At another quarry, located just west of the same road and 0.6 mile south of Union at elevation 2075′ B., the Pickaway Limestone has been quarried for road material, being black and hard and containing black chert nodules, and having the stylolitic structure that is common to this member in Monroe County. A large amount of the stone is exposed without cover along this ridge.

A little less than one mile north of Union a quarry has been operated in the Pickaway Limestone slightly east of the Pickaway road, the product having been used in surfacing this highway. Here the stone is black, hard, and stylolitic.

The **Charles A. Cadle Limestone Quarry,** located just west of the Union-Pickaway road and one mile southwest of Pickaway, shows a stone that is bluish-black, hard, close-grained, and stylolitic, being much slickensided along the lines of vertical cleavage. The quarry is about 100 feet long by 50 feet

wide and 5 to 10 feet deep, the product having been used for local road material with good success. A sample (No. 610R) was collected from this quarry, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter, and is probably as nearly a representative sample of the Pickaway Limestone as could well be found, its calcium carbonate content being 70 per cent., with 21.2 per cent. of silica and 5.3 per cent. of magnesium carbonate.

TAGGARD LIMESTONE.

The **Taggard Limestone,** previously described on pages 476-479, is a bed of white oolite, seldom more than 5 to 10 feet thick and often not more than two to three feet, coming near the middle of the Greenbrier Series and usually marked by beds of red shale above and below it. In physical structure this thin bed would appear to be quite well suited for building stone, since it is soft enough to be split or chiseled with comparative ease and it has a pleasing white texture, but as a practical quarrying proposition it offers little opportunity for exploitation in competition with the more abundant deposits, of similar nature but of earlier deposition, in the Mississippi Valley. Its outcrops have been fully discussed in the above reference.

PATTON LIMESTONE.

The **Patton Limestone,** described on pages 480-483, is a heavy and usually massive bed, partly shaly or sandy but usually having a thick zone of hard, blue limestone. The total formation varies from 100 to 250 feet in thickness of which one-third or one-half is nearly always hard, pure stone. At many localities it very much resembles the Union Limestone but aside from paleontological differences it can usually be distinguished by its darker color and occasional nodules of black chert, as well as by its stratigraphic associations which should not be difficult to follow in regions where the geologic structure has been defined.

In Mercer County the Patton Limestone apparently has

not been quarried but it is often a heavy bed, its position and characteristics being indicated in the Stony Gap Section, page 199, and in the Lurich Section, page 204, the latter being in the edge of Giles County in the narrows of New River. At the latter point the stone is gray, hard, and apparently pure.

In Monroe County no quarries were noted in the Patton Limestone but there are numerous good exposures. At the **Arthur McDaniel Limestone Exposure,** located in the plateau 0.3 mile south of Patent School and one mile south of Nickells Mill at elevation 2095′ B., there is a 30-foot reef of pure gray limestone on the eastern side of the road, the dip being southeastward at the rate of 30 degrees. A sample (No. 612R) was collected from this outcrop, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. This reef contains 92.6 per cent. of calcium carbonate and less than 1 per cent. of magnesium carbonate.

At the **Luther Bird Limestone Exposure** in the valley of Second Creek, 0.4 mile southeast of Patton and at the type locality of the Patton Limestone, the entire formation is 210 feet thick with its base at elevation 1950′ B., as indicated in the Patton Section, page 228, and with a 40-foot bed of gray, pure, cavernous stone at the base. From this a sample (No. 613R) was collected, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

At the **Nelson Hawkins Limestone Exposure,** located north of the Pickaway-Hillsdale road 0.6 mile southeast of Pickaway at elevation 2175′ B., the Patton Limestone makes a prominent reef about 75 feet thick, dipping northwestward at an angle of 15 degrees and containing many marine fossils, as indicated by **Fossil Lot 146 on Map IV.** The stone is dark and granular toward the west and gray or dark toward the east with some black chert at the base. A sample (No. 611R) was collected from this reef, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

The analyses of the three samples of Patton Limestone collected in Monroe County reveal a stone that is sufficiently high in calcium carbonate to make good agricultural lime and

at the same time sufficiently low in magnesium carbonate to make its use for Portland cement quite possible. For the latter purpose, however, it would be necessary to mix the quarried material with shale in order to have enough alumina and silica.

SINKS GROVE LIMESTONE.

The **Sinks Grove Limestone,** previously described on pages 484-489, is a massive bed of blue, hard, somewhat sandy and impure material, with a large amount of black chert occurring mostly in the form of nodules scattered through its mass. In thickness it varies from about 175 feet in northern Monroe County to more than 300 feet in southern Mercer. It can usually be distinguished from the overlying Patton Limestone by the very much larger proportion of included chert as well as by its darker color and more sandy nature. At its base, however, it goes almost imperceptibly into the Hillsdale Limestone which is also dark but which usually contains a still larger amount of black chert as well as more distinct streaks of sandy material, and also exhibits many faunal differences as already noted. On account of the nodules of black chert it is not apparent that the Sinks Grove Limestone will be much favored in any phase of the limestone industry where chemical qualities are directly involved, although there are local exposures at which considerable quantities of the stone might be quarried without much objectionable chert. On account of its hard and durable nature it is very well suited for concrete aggregate or road material.

The **William Kaufman Limestone Quarry,** located in Mercer County in the eastern end of Bluefield south of the Norfolk and Western Railway and just south of Princeton Avenue and 1.2 miles eastward from the railroad station, at elevation 2510′ B., is apparently in the Sinks Grove Limestone since it contains a large amount of black chert and its fauna, including large brachiopods, crinoids, and many bryozoa, is much the same as this member contains at other localities where more positive stratigraphic evidence is available. Here the rocks are overturned and now dip southward at an angle of

48 degrees. At the northern edge of the quarry the stone is dark and hard but toward the south it becomes more yellow and shaly. The quarry, which is now entirely abandoned, was worked northeastward about 200 feet against the butts of the strata and across a thickness of 100 feet, with a height of 75 feet. Among other uses some of the material was burned in a draw-kiln for the production of lime.

The **Ward Bailey Limestone Exposure,** located on a southern branch of East River southeast of the Bluefield water pump station and 0.6 mile south of Stony Gap at elevation 2315′ B., exhibits a thickness of 300 feet of hard, blue limestone containing a great amount of black chert and also numerous marine fossils as noted at **Fossil Lot 112 on Map II.** This very considerable thickness, recorded as No. 91 of the Stony Gap Section, page 199, is not the entire amount of Sinks Grove Limestone of that locality, since its lower part was not distinguished from the Hillsdale Limestone contained in No. 92 of the section. A sample (No. 591R) was collected from the calcareous matrix, excluding the chert, its composition being published in the Table of Limestone Analyses at the end of this Chapter. This sample contains 86.45 per cent. of calcium carbonate and 9.74 per cent. of silica, but if the siliceous chert had been included the percentage of silica would have been considerably enlarged.

On the western side of the narrows of New River in the edge of Giles County, Virginia, the Sinks Grove Limestone is well exposed, as exhibited in the Lurich Section, page 204, but not therein entirely differentiated from the Hillsdale Limestone. At this locality it is split by a stratum of shaly and calcareous sandstone 40 feet thick, but the remainder is a hard limestone with black chert in the lower part.

In Monroe County the Sinks Grove Limestone has not been quarried, so far as known, but in the vicinity of Sinks Grove it is noted in the Bickett Knob Section, page 225, being mostly a blue, hard, and massive limestone containing much black chert, and this being its general nature throughout the county.

HILLSDALE LIMESTONE.

The **Hillsdale Limestone,** previously described on pages 487-490, is the basal member of the Greenbrier Series, being usually black, hard, and massive toward the top but containing streaks of sandy shale toward its base and having abundant quantities of black chert throughout most of its mass. In thickness it varies from 50 to 150 feet. Its upper part might be used for concrete aggregate or road material but the great amount of chert contained would apparently preclude its successful use in the manufacture of cement or lime.

LIMESTONES OF THE ORDOVICIAN PERIOD.

In contrast to the almost total absence of limestone in the Devonian and Silurian Periods of the local area, the Ordovician Period contains a vast amount of calcareous material, both limestone and dolomite. Some of these beds are so earthy or so much interstratified with shales that their use as commercial material would hardly be possible, but others are of such exceptional purity that they can be equaled in few other regions of the Appalachian States. At the bottom of the Ordovician, however, as well as in the lower strata that are presumably of Cambrian age, the beds are almost entirely dolomitic with only infrequent streaks of pure lime. The following table indicates in descending order the calcareous beds of the Ordovician and of the supposed Cambrian that deserve economic discussion:

Martinsburg Series:
  Eden Group
  Trenton Group
Moccasin Limestone.
Stones River (Chickamauga) Limestone.
Beekmantown Limestone (dolomitic).
Elbrook Limestone? (dolomitic).

LIMESTONES OF THE MARTINSBURG SERIES.

LIMESTONES OF THE EDEN GROUP.

The **Eden Group,** previously described on pages 613-14, appears to be mostly composed of shale in the southwestern

part of Mercer County but farther east in the narrows of New River, Giles County, Virginia, and along the northern front of Peters Mountain in Monroe County, its lower portion is made up of blue, flaggy, crystalline limestones usually separated by thin streaks of shale, as exhibited in the Rich Creek Section, pages 210-211, and the Hanging Rock Section, pages 234-235. It is not apparent that these flaggy beds would be of much use as masonry stone because they have little artistic texture and because their physical nature is such that they could not readily be worked into desirable shapes, although they might be employed to a limited extent as local stone for bungalows and other small structures. As broken stone for concrete or road material they are poorly adapted on account of the interstratified shales.

If the Portland cement industry should become developed in this region, however, these limestones might become of much value as mixing agents to reduce the percentage of lime obtained from the very pure Stones River (Chickamauga) Limestone or possibly for use in connection with the limestones of the Trenton Group which lie just below those of the Eden.

LIMESTONES OF THE TRENTON GROUP.

The **Trenton Group,** previously described on pages 614-15, is largely composed of blue, flaggy, and highly crystalline limestones interstratified with thin beds of calcareous shales. This group has a thickness of several hundred feet, its maximum being about 750 feet and its principal outcrop being along the northern fronts of East River Mountain and Peters Mountain, for a total distance of more than 60 miles in Mercer and Monroe Counties and the included part of Giles County, Virginia, in the narrows of New River. In the southwestern part of Mercer County little limestone of this age is apparent but farther east it becomes noticeable, and in the narrows of New River, as indicated in the Rich Creek Section, page 211, the Trenton Group is 731 feet thick and is largely limestone. In the Hanging Rock Section of Monroe County, pages 235-237, the group is recorded as 322 feet thick.

As construction material the remarks concerning the Eden Group would apply closely to the Trenton. As possible material for the manufacture of Portland cement the Trenton limestones are of very much interest, since the beds of this same group have long been extensively quarried by many of the cement mills in the Lehigh Valley of eastern Pennsylvania, where they often show a composition that is almost ideal for grinding without admixture of shale, so that the cost of manufacture is much decreased. In the local territory these beds may be quarried with ease along the extensive outcrop mentioned and if their composition does not prove to be ideal for cement at all points the more shaly strata of the Eden Group or the more calcareous Stones River Limestone, both available along the same slope, may be added in desired proportions. The favorable occurrence of vast quantities of high-volatile coal along both the Norfolk and Western and Virginian Railways in counties slightly farther west is a factor of prime importance in this connection. No samples of the Trenton limestones were taken for chemical analyses.

MOCCASIN LIMESTONE.

The **Moccasin Limestone,** previously described on pages 616-20, is a red, argillaceous, and earthy deposit, varying in thickness from 400 to 450 feet, and principally outcropping along the northern bases of East River Mountain and Peters Mountain, as well as in the narrows of New River in the edge of Giles County, Virginia. So far as known this limestone has not been quarried for any use in the local area and it would hardly be suited for construction purposes on account of its general tendency toward disintegration.

At the **Floyd Dickson Limestone Exposure,** located on the head of Pigeon Creek 2 miles southward from Oakvale and one mile northeast of Buckhorn Knob, at elevation 2505′ B., a sample (No. 580R) was collected from the lower 25 feet of the Moccasin, its composition being published in the Table of Limestone Analyses at the end of this Chapter. This sample shows a calcium carbonate percentage of 82.5, but on

account of the earthy material higher up, this is probably higher than would be obtained from a sample across the entire face of the formation.

It might be possible that the Moccasin Limestone in some cases could be used as a mixing agent with the Trenton or Stones River in the manufacture of Portland cement, and it is also possible that at some localities it might have a composition that would make it desirable as the major ingredient of cement. A further intensive study of the formation would be necessary to determine this point.

STONES RIVER (CHICKAMAUGA) LIMESTONE.

The **Stones River (Chickamauga) Limestone,** previously described on pages 620-30, and indicated on Figures 12 and 13, pages 456 and 457, respectively, as well as outcropped in detail on Maps II and IV, is a large deposit of almost pure calcium carbonate varying in thickness from 500 to 700 feet, which outcrops principally along the northern bases of East River Mountain and Peters Mountain, as well as in the narrows of New River in the edge of Giles County, Virginia, the total length of the exposure being more than 60 miles. It can be distinguished readily from the overlying Moccasin by the red color of the latter and from the underlying Beekmantown by its marked tendency toward weathering into large sink-holes, as well as by its physical structure and marine fossils. Its upper two-thirds (Upper Stones River) is gray or dove-colored, with several zones of pure stone, but the lower third (Middle Stones River) is dark and frequently contains nodules of black chert, although the matrix is often quite high in calcium carbonate.

This limestone would hardly be suitable for use as a building stone since it has an irregular fracture. At many localities it would doubtless prove to be satisfactory as crushed stone for concrete aggregate or road material, although its use as such would appear to be uneconomical on account of its value for many purposes where a pure limestone is demanded. On the basis of its analysis it appears to be well adapted for

blast-furnace flux, agricultural lime, wall plaster or lime mortar, Portland cement, for use in the paper, glass, and tanning industries, and for many other purposes where a limestone of great chemical purity is demanded.

At the **R. F. Baker Limestone Quarry,** located in South Bluefield, Mercer County, on the south side of Beaver Pond Creek 0.4 mile eastward from the Virginia State line, at elevation 2455′ B., and at the same point as **Fossil Lot 12 on Map II,** the stone is exposed in a wedge-like area coming between two limbs of the St. Clair Fault. Here it is gray, hard, much fractured and crushed, slickensided, and containing numerous calcite veins. The quarry face is about 200 feet long, 75 feet high, and has been worked southward into the hill 100 feet, the product having been used mainly for road material. A sample (No. 579R) was collected from the quarry face, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. This sample shows only 0.94 per cent. of silica and negligible quantitites of other impurities. Owing to the disturbed condition of the rocks at this locality the exact portion of the sampled stratum with reference to the entire Stones River could not be positively determined, although it is probably near the middle of the group.

At the **S. J. Sublette Limestone Quarry,** located at the foot of East River Mountain 0.6 mile northeast of Bailey School and 1.6 miles southeast of Bluefield Station, at elevation 2745′ B., a portion of the Stones River has been worked, as already published in the local measurement at **Fossil Lots 47 and 48 on Map II,** page 625. Here the stone dips southward at an angle of 37 degrees, the bedding being natural and not overturned. The portion quarried is a gray, compact, fine-grained limestone, estimated as 75 feet thick, the excavation being about 50 by 100 feet with a depth of 10 feet into the gentle slope. Just beneath the quarry a dark granular limestone containing black chert is visible so that the quarry itself is evidently in the bottom portion of the Upper Stones River (Lebanon) member while the dark portion below is in the Middle Stones River (Ridley and Pierce). This quarry is not now in operation, its former product having been partly

used for construction purposes and partly burned into agricultural lime. A sample (No. 582R) was collected from the quarry face, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. This sample shows 1.6 per cent. of silica and 97 per cent. of calcium carbonate.

At the **Floyd Dickson Limestone Exposure,** located on the head of Pigeon Creek, Mercer County, two miles southward from Oakvale and one mile northeast of Buckhorn Knob and just south of the Dickson residence, a sample (No. 581R) was collected from the upper 50 feet of the Upper Stones River, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. This sample contains 1.94 per cent. of silica and 1.79 per cent. of alumina, being less pure than other samples obtained lower down in the strata.

In the edge of Giles County, Virginia, the Stones River Limestone is well exhibited at the **Virginian Railway Limestone Exposure** on the east side of the narrows of New River 1.5 miles south of Rich Creek Station, as recorded in the Rich Creek Section, page 211, its total thickness being 618 feet, and being partly dove-colored and pure and partly dark, with inclusions of black chert.

At the **New River Lime Company Quarry,** located in Giles County, Virginia, on the west side of New River just north of Ripplemead, the Middle Stones River portion is quarried, as indicated in the Ripplemead Section, page 212. The quarry face is 200 feet long and extends into the hill 100 feet, with a height of 100 feet, which latter figure represents the total thickness of strata being used, since the rocks are nearly horizontal at this locality. The upper portion of the quarry is black limestone with black chert and marine fossils, and the lower portion is black and crystalline being mostly metamorphosed into a black marble. The product is burned into lime at a large draw-kiln, the black chert being presumably discarded before charging the kiln. The successful production of lime from this black and cherty portion of the formation is of much interest because of its bearing on the possible use

of this stone in Mercer and Monroe Counties.

The **Kimballton Limestone Company Quarry,** located on the southern side of Stony Creek at Kimballton, Giles County, Virginia, and only two miles south of the Monroe County line, is a large operation at which the Stones River is burned into lime. A detailed investigation of this plant was not made.

At the **John McKenzie Limestone Exposure,** located on the lower northern slope of Peters Mountain, Monroe County, 1.1 miles southwest of Green Valley School and 3.1 miles southeast of Peterstown there is visible about 100 feet of dove-colored limestone, making sinks in the topography and possibly belonging slightly below the middle of the outcropping Stones River and therefore representing the upper part of the Middle Stones River member, since the visible beds to the southward and higher in the formation appear to be 300 to 400 feet thick, being composed of dark-gray, fossiliferous limestone with some fragments of black angular chert, while to the northward the basal portion of the Stones River, consisting of dark, fossiliferous limestone, makes the top of a low knob north of the sinks. The dip at this locality is southward at an angle of 14 degrees. A sample (No. 586R) was collected from the 100-foot outcrop in the sinks, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

At the **J. O. Coulter Limestone Quarry,** located on a branch of Rich Creek at the northern base of Peters Mountain two miles south of Lindside and 0.7 mile southwest of Spruce Run School, the extreme lower portion of the Middle Stones River member, next to the Beekmantown, has been burned on a small scale for agricultural lime, the elevation of the quarry being 2280′ B., and the dip being southward at an angle of 25 degrees. A sample (No. 616R) was collected from this basal 50-foot portion, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter.

In the Hanging Rock Section, page 237, the total thickness of the Stones River (Chickamauga) Limestone is 690

feet, as exposed along the northern base of Peters Mountain three miles southwest of Gap Mills where a road ascends the mountain toward Potts Valley. Here the upper and middle portions of the formation are gray or dove-colored representing the Upper Stones River member, while the lower part is dark and cherty and is apparently the Middle Stones River member, there being sink-holes in this part of the formation. A sample (No. 598R) was collected on the **E. F. Bell farm** along the mountain road, including a zone of gray limestone, 100 to 150 feet thick, coming 50 to 100 feet below the top of the Stones River and therefore being in the Upper Stones River member. Another sample (No. 597R) was collected on the same property near the road fork at the foot of the mountain, coming from 100 to 150 feet of dark stone in the sink-hole beds and representing a considerable portion of the Middle Stones River member. The compositions of both of these samples are published in the Table of Limestone Analyses at the end of this Chapter, the sample from the Middle Stones River having only 1.11 per cent. of silica, while its calcium carbonate is 98 per cent., indicating a very fine grade of stone.

At the **Tessie Howard Limestone Exposure,** located on the waters of Kitchen Creek at the northern base of Peters Mountain two miles southeast of Gap Mills and just east of the public road which ascends the mountain, a sample (No. 604R) was collected from about 100 feet of dark-gray limestone having a few marine fossils and a wavy-banded structure with dark lenses, with an elevation of 2480′ B. and a southward dip of 20 degrees. This zone appears to be about the middle of the Stones River Limestone and may be partly in the Upper Stones River and partly in the Middle Stones River. The composition of this sample is published in the Table of Limestone Analyses at the end of this Chapter, there being only 86.42 per cent. of calcium carbonate, with relatively high percentages of silica, alumina, and magnesium carbonate.

At the **Florence Lewis Limestone Exposure,** located just north of Sweet Springs Creek 0.3 mile west of Sweet Springs village and just east of the road toward Cove Creek at eleva-

tion 2025′ B., and at the same point as **Fossil Lot 58 on Map IV,** a sample (No. 606R) was collected from 50 to 100 feet of gray, fossiliferous limestone coming near the middle of the Stones River Limestone and probably in the basal portion of the Upper Stones River. The composition of this sample is published in the Table of Limestone Analyses at the end of this Chapter, its calcium carbonate being 98 per cent., with a low content of silica and other impurities.

From a study of the samples taken in the Stones River Limestone it appears that relatively high silica may be expected in the extreme upper part of the Upper Stones River member and that low silica is the usual rule in the sink-hole zone which lies partly in the Upper Stones River and partly in the Middle Stones River and near the middle of the entire group. A low silica content is found in the lower part of the Middle Stones River member next to the Beekmantown at some localities where it is free from objectionable chert. In order to determine with exactitude the full possibilities of this great belt of limestone it would, of course, be necessary to collect many more samples from the various zones of the formation at several different localities along the outcrop. Such a detailed study has been impossible on account of the numerous other requirements for time in the present Report but it is believed that the samples published are so assuring that further investigations of this nature on the part of corporations or individuals engaged in the limestone industry may be safely recommended.

It is evident that the quarrying possibilities of this formation are very good, since its principal outcrop is quite uniform along the bases of East River Mountain and Peters Mountain where the beds dip southward into the gentle slope of the mountains at an angle varying from 10 to 30 degrees, so that they can be continually followed from place to place without the expensive prospecting that is often required where the strata have been extremely folded or faulted. Along most of the outcrops, also, there is a low belt of topography, or an upland valley, through which railroads can be built without exorbitant cost from various points on the three trunk-line systems

which may be regarded as serving the territory since both the Norfolk and Western and Virginian Railways pass across the deposits in the narrows of New River and farther west can be reached with short spurs along the tributaries of East River, while the Chesapeake and Ohio, farther north, is only ten miles from Sweet Springs, by a water grade.

BEEKMANTOWN LIMESTONE.

The **Beekmantown Limestone,** previously described on pages 630-44, and indicated by outcrop on Maps II and IV, is an immense assemblage of dolomites and dolomitic limestones with occasional strata of relatively pure limestone, the total exposed thickness being about 3,500 feet. As already discussed, the upper 2,500 feet have been identified by Dr. Prouty as belonging to the Beekmantown Limestone of Ordovician age while the lower 1,000 feet have been tentatively considered as the Elbrook Limestone of the Cambrian Period, although mapped with the Beekmantown for lack of paleontological evidence. The upper 2,500 feet of beds, herein generally referred to as the "Beekmantown proper", will be first considered.

The **Beekmantown proper,** as shown by the general section on pages 632-3, has a heavy chert zone at the top (Narrows Chert) from which the dolomitic matrix has mostly weathered out leaving little in view at most exposures except the granular chert. Farther down there are alternating limestones and dolomites most of which contain a vast amount of interbedded, or in some cases concretionary, chert having much the same color as the matrix and making a troublesome factor in the use of the stone for purposes where the chemical quality is a matter of importance.

It is not apparent that the occasional strata of relatively pure limestone noted in the general section can be regarded as constant features of the formation, although they are occasionally found in the stratigraphic positions noted. It is quite possible that these beds of limestone may represent local areas in which the supposed original content of calcium carbonate

has not been replaced by later infiltrations of magnesium and that in other localities the normal replacement may have occurred in these same beds. It is thus evident that careful prospecting should be done before attempting to utilize any of the supposed lime belts of the Beekmantown proper for purposes in which a comparatively high content of calcium carbonate is desired.

In the few analyses available no beds of sufficiently low silica to be desirable for use in open-hearth steel manufacture were discovered in the dolomitic members of the Beekmantown, the range in silica being approximately between 4 and 16 per cent. Strictly speaking, also, these beds are not sufficiently magnesian to class them as theoretical dolomites, the highest percentage of magnesium carbonate found being 38.25 per cent. as compared to the 45.7 per cent. required for pure dolomites. They are, therefore, more properly magnesian or dolomitic limestones, but for practical purposes they may be regarded as dolomites and such usage has been followed in this Report.

Probably the most useful purpose to which the various members of the Beekmantown may be put is that of crushed stone for concrete aggregate and road material. For this purpose the entire formation, with the exception of the Narrows Chert member, is well adapted, since the stone is massive and quite durable as is fully attested by the great reefs which may be generally noted and which often form ridges of considerable extent. In many of these reefs the stone could be quarried at extremely low cost and on as extensive a scale as might be desired. It is, of course, possible that occasional areas may be found where the calcium carbonate is sufficiently high to permit the use of the stone in the manufacture of lime for the agricultural and building trades.

The Beekmantown proper outcrops across the southern end of Mercer County in a series of low foot-hills just north of East River Mountain, there being an intermediate lower area occupied by the pure Stones River Limestone which often dissolves, leaving sink-holes. In the narrows of New River, the outcrop crosses the northern end of Giles County, Vir-

ginia. Farther east it extends along the foot-hills of Peters Mountain to the vicinity of Zenith and Crimson Springs, beyond which it mainly occupies the valleys of Back, Kitchen, and Sweet Springs Creeks.

The **Bodenhamer & Tabor Limestone Quarry,** located in South Bluefield, Mercer County, just northeast of Bailey School and 1.3 miles southeast from Bluefield Station, at elevation 2715' B., is in a heavy reef of dolomite coming slightly below the Narrows Chert and possibly being the same at No. 3 of the general section, page 632. Here the strata dip southeastward at an angle of 43 degrees, the bedding being natural and not overturned, and the stone being dark-gray and hard. The quarry is 100 feet long, by 50 feet into the hill, and has a height of 25 feet. The product is crushed in a Champion crusher and used for streets and other construction purposes around Bluefield. A sample (No. 584R) was collected across the quarry face, its composition being published in the Table of Limestone Analyses at the end of this Chapter.

In Giles County, Virginia, a sample (No. 590R) was collected on unknown property on a low spur of Wolf Creek Mountain, south of Wolf Creek, west of Mill Creek, and two miles southwest of Narrows, from 158 feet of gray dolomite recorded as No. 10 of the Narrows Section, page 206, and being apparently the same zone as No. 3 of the general section. The composition of this sample is published in the Table of Limestone Analyses at the end of this Chapter.

At the **Virginian Lime Corporation Quarry,** located in Giles County, Virginia, on the east side of New River along the Virginian Railway slightly north of Ripplemead, a gray dolomite or magnesian limestone, having a thickness of 285 feet as indicated in the Snidows Ferry Section, page 213, is utilized, this bed being apparently much the same as No. 3 of the general section. Here there is a gentle southward dip of about 8 degrees, the quarry face being 2,100 feet long and extending 200 feet into the hill, while its height at some points is as much as 180 feet. According to W. B. Bobbitt, Superintendent, the plant produces crushed stone for road material and concrete aggregate, and also ground agricultural lime, the

calcium carbonate content of which is about 50 per cent. The equipment includes a large Power Mining and Machinery Company crusher, and four smaller Allis-Chalmers crushers, and large dump cars which are operated by electrical control from the crusher house. The output of this plant is about 3,000 tons daily, its head office being at Chicago, Illinois. No sample of this stone was secured, the examination of the quarry having been made in an incidental manner in the course of stratigraphic studies by Dr. Prouty and the writer.

At the **Frank Harshbarger Limestone Exposure,** located on the headwaters of Crooked Creek, Monroe County, 0.7 mile southwest of Green Valley School and 3.1 miles east of Peterstown, a sample (No. 619R) was collected from a 50-foot reef of hard, gray limestone, at elevation 2200′ B., being about 300 feet south of the St. Clair Fault and several hundred feet below the top of the Beekmantown proper, its more exact stratigraphic position not being determined. The composition of this sample is published in the Table of Limestone Analyses at the end of this Chapter, the calcium carbonate being 93.4 per cent. although in physical appearance the stone can scarcely be distinguished from a dolomite.

At the **S. H. Crosier Limestone Exposure,** located along the road which ascends a branch of Dropping Lick Creek 0.7 mile west of Wallace School and 1.9 miles southwest of Zenith, Monroe County, at elevation 2245′ B., a sample (No. 618R) was collected from a 50-foot reef of gray dolomite belonging possibly about 1,500 feet below the top of the Beekmantown proper. Here the dip is southward at an angle of 34 degrees. The composition of this sample is published in the Table of Limestone Analyses at the end of this Chapter, its calcium carbonate being only 46.5 per cent. with relatively high percentages of silica and magnesium carbonate.

The calcareous beds exposed below the Beekmantown proper and consisting of 700 to 1,000 feet of gray or yellowish-buff dolomites with thin partings of shale, and herein tentatively correlated as the Elbrook Limestone of Cambrian age, outcrop at only a few localities in the local territory.

In Mercer County they occur for perhaps two miles along

a strip just south of the St. Clair Fault and extending eastward from South Bluefield to Grassy Branch and perhaps a little beyond. Farther east in the same county it is possible that some of these beds are exposed on Pigeon Creek and the head of Big Spring Branch just south of the St. Clair Fault although a positive identification was not made.

In Monroe County there may be a fringe of them on the southern slope of Gap Mountain west of Gap Mills, but this locality, also, is doubtful. In the edge of Giles County, Virginia, they do not occur along with the Beekmantown outcrop just south of the St. Clair Fault in the narrows of New River, but about two miles farther south they are visible on the western side of the river at the mouth of Wolf Creek slightly north of Narrows town, as recorded in Nos. 30-39, inclusive, of the Narrows Section, page 207.

At the **Goodykoontz Drug Company Limestone Exposure**, located in South Bluefield, Mercer County, at the intersection of Bland and South Streets just north of Beaver Pond Creek and apparently just southeast of one limb of the St. Clair Fault, what appears to be the Elbrook Limestone was exposed in the excavation for the building of this company. Here the stone is dark and extremely hard with streaks of calcite, being much slickensided and dipping southward at an angle of 60 degrees but not overturned. A sample (No. 585R) was collected across the face of about 25 feet of strata in this basement, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. The analysis shows 6.79 per cent. of silica, 90.3 per cent. of calcium carbonate, and only 1.17 per cent. of magnesium carbonate. From the calcium carbonate it might be inferred that the exposure belongs to the Stones River Limestone rather than the Elbrook, since the former makes a tongue or wedge that extends eastward almost to this locality between two limbs of the St. Clair Fault. This might possibly be the case, but from the content of silica as well as from the absence of marine fossils it is considered as the Elbrook.

At the **W. T. Owen Limestone Quarry**, located in the western edge of South Bluefield north of the southern branch

of Beaver Pond Creek and 0.9 mile southeast of Bluefield Station, at elevation 2595′ B., the upper part of the Elbrook was being quarried in the summer of 1922, the operation being reported as of temporary character and designed to utilize stone removed from the excavation for a building. The stone is gray, hard, and oolitic, dipping southeastward at an angle of 52 degrees but not overturned. The quarry face is 100 feet long by 50 feet into the hill and 25 feet high. The product was being crushed in a Boss Brothers Engineering Company crusher at the rate of 60 to 80 cubic yards daily and trucked to Bluefield for street and other construction work. A sample (No. 583R) was collected from this quarry, the composition of which is published in the Table of Limestone Analyses at the end of this Chapter. This sample shows only 37.9 per cent. of calcium carbonate and relatively high percentages of silica and magnesium carbonate.

The entire ridge between the two branches of Beaver Pond Creek at this locality appears to be made up of the Elbrook Limestone, there being many fragments of its weathered chert along the slopes, as well as outcroppings of the matrix.

TABLE OF LIMESTONE ANALYSES.

The following table gives in compact form the results of the chemical tests made on the limestones of Mercer, Monroe, and Summers Counties, the samples having been taken in the field by the writer, with a little assistance from Dr. Prouty and Mr. Price, and the analyses made by Mr. B. B. Kaplan, Chemist of the Survey. Following the table are brief references to the formations and portions of the same sampled, property ownership, location of outcrop or quarry, and page of the text where described in full, the reference numbers being the same as those in the second column of the table:

Table of Limestone Analyses, Mercer, Monroe, and Summers Counties.

Sample No.	Reference No.	NAME OF LIMESTONE.	Silica, (SiO_2)	Ferric Iron. (Fe_2O_3)	Alumina. (Al_2O_3)	Calcium Carbonate. ($CaCO_3$)	Magnesium Carbonate. ($MgCO_3$)	Phosphoric Acid. (P_2O_5)	Loss on Ignition.	Total.
632R	1	Avis	13.60	0.40	1.54	82.40	0.60	0.04	1.17	99.84
630R	2	Avis	44.40	1.13	5.09	45.20	1.89	0.06	2.01	99.78
Average		**Avis**	**29.00**	**0.76**	**3.32**	**63.80**	**1.24**	**0.05**	**1.59**	**99.81**
641R	3	Alderson	40.52	2.27	3.13	51.00	1.10	....	1.85	99.87
595R	4	Union	22.20	0.87	1.11	55.15	20.60	0.06	0.42	100.41
593R	5	Union	6.48	0.67	1.67	88.80	1.53	....	0.63	99.78
640R	6	Union	16.20	0.98	0.92	78.00	1.19	....	2.37	99.66
639R	7	Union	29.00	1.72	2.78	61.98	1.20	....	2.58	99.26
638R	8	Union	7.00	0.68	0.62	91.00	0.68	....	0.32	100.30
620R	9	Union	28.84	0.91	1.10	65.51	1.21	0.043	2.01	99.62
621R	10	Union	5.80	0.24	0.96	91.00	0.86	0.025	1.17	100.05
622R	11	Union	8.40	0.86	1.14	87.00	1.25	0.03	1.70	100.38
623R	12	Union	2.10	0.37	0.68	96.80	0.38	Trace	0.21	100.54
624R	13	Union	6.15	0.71	1.04	90.15	0.62	0.04	0.83	99.54
Average		**Union**	**13.22**	**0.80**	**1.20**	**80.54**	**2.95**	**0.05**	**1.22**	**99.95**
594R	14	Pickaway	27.20	1.48	2.22	60.60	7.96	0.02	0.87	100.35
592R	15	Pickaway	13.04	0.85	1.03	84.05	0.71	....	0.74	100.42
596R	16	Pickaway	7.96	0.52	0.70	87.20	1.14	0.022	2.05	99.59
610R	17	Piekaway	21.20	1.14	2.14	70.00	5.30	0.04	0.63	100.45
Average		**Pickaway**	**17.35**	**1.00**	**1.52**	**75.26**	**3.78**	**0.03**	**1.07**	**100.20**
612R	18	Patton	3.94	0.26	0.92	92.60	0.91	0.04	1.00	99.67
613R	19	Patton	7.96	0.36	0.69	89.60	1.00	0.04	0.97	100.62
611R	20	Patton	3.70	0.21	0.79	93.40	0.87	0.02	0.76	99.75
Average		**Patton**	**5.20**	**0.28**	**0.80**	**91.87**	**0.93**	**0.03**	**0.91**	**100.01**
591R	21	Sinks Grove	9.74	1.42	1.26	86.45	0.87	....	0.76	100.50
580R	22	Moecasin	13.76	1.06	1.18	82.50	0.91	0.011	1.06	100.48
579R	23	Stones River	0.94	0.10	0.38	97.65	0.48	Trace	0.61	100.36
582R	24	Stones River	1.60	0.23	0.57	97.00	0.47	Trace	0.23	100.10
581R	25	Stones River	1.94	0.64	1.79	94.23	0.22	Trace	1.00	99.82
586R	26	Stones River	1.33	0.44	0.90	95.05	1.47	0.018	1.00	100.19
616R	27	Stones River	1.12	0.12	0.59	97.58	0.64	Trace	0.18	100.23
598R	28	Stones River	4.90	0.26	4.30	87.00	3.45	0.014	0.47	100.39
597R	29	Stones River	1.11	0.15	0.45	98.00	0.25	Trace	0.34	100.30
604R	30	Stones River	5.20	0.28	3.94	86.42	3.70	....	0.37	99.91 (a)
606R	31	Stones River	1.30	0.10	0.48	98.00	0.21	Trace	0.24	100.33
Average		**Stones River**	**2.16**	**0.26**	**1.49**	**94.55**	**1.21**	**0.016**	**0.49**	**100.19**
584R	32	Beekmantown proper	4.64	0.48	1.15	58.75	33.90	0.003	1.04	99.96
590R	33	Beekmantown proper	5.51	0.38	0.72	54.24	38.25	0.005	0.62	99.72
619R	34	Beekmantown proper	3.75	0.20	0.95	93.40	0.87	0.04	0.72	99.93
618R	35	Beekmantown proper	15.88	0.18	0.82	46.50	36.50	0.03	0.56	100.47
Average		**Beekmantown proper**	**7.44**	**0.31**	**0.91**	**63.22**	**27.38**	**0.019**	**0.74**	**100.02**
585R	36	Elbrook?	6.79	0.64	1.01	90.30	1.17	0.025	0.61	100.52
583R	37	Elbrook?	21.10	0.81	1.32	37.90	35.50	0.005	3.10	99.73
Average		**Elbrook?**	**13.94**	**0.73**	**1.16**	**64.10**	**18.33**	**0.015**	**1.86**	**100.12**

(a) Moisture also reported in this sample, 0.013 per cent.

1. Avis member of Mauch Chunk, B. K. Litsinger, Keeney Mountain road, 1 mile S. E. of Hinton, Summers Co.; see p. 695.
2. Avis member of Mauch Chunk, Wiley McGraw, Tallery Mountain road, 1.4 mi. south of True, Summers Co.; see p. 696.
3. Alderson member of Greenbrier, W. H. Preston, 0.5 mile N. W. of Wills Station, Mercer Co.; see p. 699.
4. Union member of Greenbrier, McDowell County Stone Quarry, just west of Nemours village, Mercer Co.; see pp. 700-1.
5. Union member of Greenbrier (100-ft. ledge), Crollins Stone Co. Quarry, 1.6 mi. east of Bluefield Station, Mercer Co.; see p. 701.
6. Union member of Greenbrier (upper 60 ft.), W. H. Preston, 0.4 mile N. W. of Wills Station, Mercer Co.; see pp. 702-3.
7. Union member of Greenbrier (next lower 60 ft.), W. H. Preston, 0.4 mile N. W. of Wills Station, Mercer Co.; see pp. 702-3.
8. Union member of Greenbrier (next lower 10 ft.—oolite), W. H. Preston, 0.4 mile N. W. of Wills Station, Mercer Co.; see pp. 702-3.
9. Union member of Greenbrier (50-ft. portion), Otto Williams Quarry, 2.7 mi. S. W. of Lindside, Monroe Co.; see p. 704.
10. Union member of Greenbrier (50-ft. portion), Frank Matty, 0.9 mi. east of Greenville, Monroe Co.; see p. 704.
11. Union member of Greenbrier (20-ft. portion), Dr. J. C. Hughes Heirs, 1.3 mi. S. W. of Johnson Crossroads, Monroe Co.; see pp. 704-5.
12. Union member of Greenbrier, Johnson and George, 0.4 mi. S. W. of Johnson Crossroads, Monroe Co.; see p. 705.
13. Union member of Greenbrier (100-ft. ledge), C. M. Hinkle, 2.1 mi. west of Sinks Grove, Monroe Co.; see p. 705.
14. Pickaway member of Greenbrier (100-ft. ledge), Baker Stone Co. Quarry, 1.3 mi. east of Bluefield Station, Mercer Co.; see p. 706.
15. Pickaway member of Greenbrier (upper 75 ft.), Ward Bailey Quarry, 0.5 mi. south of Stony Gap, Mercer Co.; see pp. 706-7.
16. Pickaway member of Greenbrier, Mrs. Geo. Davidson Quarry, 1.3 mi. south of Union, Monroe Co.; see p. 707.
17. Pickaway member of Greenbrier, Chas. A. Cadle Quarry, 1 mi. S. W. of Pickaway, Monroe Co.; see pp. 707-8.
18. Patton member of Greenbrier (30-ft. reef), Arthur McDaniel, 1 mi. south of Nickells Mill, Monroe Co.; see p. 709.
19. Patton member of Greenbrier (lower 40 ft.), Luther Bird, 0.4 mi. S. E. of Patton, Monroe Co.; see p. 709.
20. Patton member of Greenbrier (75-ft. reef), Nelson Hawkin, 0.6 mi. S. E. of Pickaway, Monroe Co.; see p. 709.
21. Sinks Grove member of Greenbrier (upper 300 ft.), Ward Bailey, 0.6 mi. south of Stony Gap, Mercer Co.; see p. 711.
22. Moccasin (lower 25 ft.), Floyd Dickson, 2 mi. south of Oakvale, Mercer Co.; see pp. 714-15.
23. Stones River, R. F. Baker Quarry, South Bluefield, Mercer Co.; see p. 716.
24. Stones River (lower 75 ft. of Upper Stones River), S. J. Sublette Quarry, 1.6 mi. S. E. of Bluefield, Mercer Co.; see p. 716.
25. Stones River (upper 50 ft.), Floyd Dickson, 2 mi. south of Oakvale, Mercer Co.; see p. 717.
26. Stones River (upper 100 ft. of Middle Stones River), John McKenzie, 3.1 mi. S. E. of Peterstown, Monroe Co.; see p. 718.
27. Stones River (lower 50 ft.), J. O. Coulter Quarry, 2 mi. S. W. of Lindside, Monroe Co.; see p. 718.

28. Stones River (100 to 150 ft. of Upper Stones River), E. F. Bell, 3 mi. S. W. of Gap Mills, Monroe Co.; see p. 719.
29. Stones River (100 to 150 ft. of Middle Stones River), E. F. Bell, 3 mi. S. W. of Gap Mills, Monroe Co.; see p. 719.
30. Stones River (100 ft., partly Upper and partly Middle Stones River), Tessie Howard, 2 mi. S. E. of Gap Mills, Monroe Co.; see p. 719.
31. Stones River (lower 50 to 100 ft. of Upper Stones River), Florence Lewis, 0.3 mi. west of Sweet Springs, Monroe Co.; see pp. 719-20.
32. Beekmantown proper (reef about 300 ft. below top), Bodenhamer & Tabor Quarry, South Bluefield, Mercer Co.; see p. 723.
33. Beekmantown proper (158-ft. reef coming 309 ft. below top), unknown property, 2 mi. S. W. of Narrows, Giles Co., Va.; see p. 723.
34. Beekmantown proper (50-ft. reef several hundred feet below top), Frank Harshbarger, 3.1 mi. east of Peterstown, Monroe Co.; see p. 724.
35. Beekmantown proper (50-ft. reef about 1,500 feet below top), S. H Crosier, 1.9 mi. S. W. of Zenith, Monroe Co.; see p. 724.
36. Elbrook? (25 ft. of lower part), Goodykoontz Drug Co., South Bluefield, Mercer Co.; see p. 725.
37. Elbrook? (50 ft. of upper part), W. T. Owen Quarry, South Bluefield, Mercer Co.; see pp. 725-6.

CHAPTER XV.

WATER-POWER, MINERAL WATERS, IRON ORE, MANGANESE, PRECIOUS METALS, AND FORESTS.

WATER-POWER.

PRESENT DEVELOPMENT.

No utilization of the streams of Mercer, Monroe, and Summers Counties for hydroelectric power has been made. In the regions where coal is not readily available, however, small water-wheel mills have been built to grind grain and saw lumber for local needs but even these are few in number and of small consequence.

In 1924 the **West Virginia Power Company,** reported as having the financial backing of the powerful firm of **Henry L. Doherty and Company,** began a large development in Summers County along New River south of Hinton. Scores of diamond drill holes were bored across the valley and bed of the river in the three-mile strip lying between the mouths of Greenbrier and Bluestone Rivers and a site for a dam was selected slightly above and south of the mouth of Greenbrier River and slightly south of Bellepoint, there being an excellent foundation afforded by the massive Stony Gap (Hinton) Sandstone which dips beneath the river bed along the Bellepoint Syncline and has a thickness of 50 to 75 feet. Plans were made for a dam 125 feet or more in height, which would have impounded the water of New River for a distance of 35 miles to the town of Narrows, Virginia, and of Bluestone River for six or seven miles, or nearly to the Mercer County line. Probably few more advantageous locations for hydroelectric

projects could be found in West Virginia, since there is a good foundation for a dam at Bellepoint without danger of seepages through limestone or other cavernous or porous strata, and also the valleys of New and Bluestone Rivers in the proposed flood area are thinly populated and have no railroads except in the narrows of New River below Narrows town where slight, if any, elevation of the grades would be required, and since no coals or other minerals of much value would be covered. After an expenditure of many hundreds of thousands of dollars the entire project is now in abeyance, presumably because of the failure to secure more favorable legislation regarding such enterprises than is now afforded by the laws of West Virginia.

AVAILABLE STREAMS.

New River.—The drainage basin of New River has already been described, pages 90-91, with a reference to published stream gages, and on page 49 will be found a record of the rainfall at Hinton.

There is no doubt that this river is capable of furnishing a large amount of power and that the valley above the mouth of Greenbrier River has many desirable points in its favor for a plant location, as already detailed under the last heading. Below the mouth of Greenbrier River the railroads and towns in Summers County could not be flooded without prohibitive damages so that high dams below Hinton do not appear feasible but at Sandstone Falls, one mile south of and above Sandstone village, there is a 25-foot cataract that could doubtless be utilized to good advantage, especially if the flow of water could be more nearly equalized by storage dams farther up the valley as would be the case if a dam should be built at Bellepoint.

Greenbrier River.—The drainage basin of Greenbrier River, tributary to New River at Bellepoint, Summers County, has already been described, pages 95-97, together with references to stream gages which have been maintained at Alderson for 30 years and which have been published in various Water-Supply Papers of the United States Geological Survey. This

river has only a moderate rate of fall and at various localities along its course through Summers and Monroe Counties there are narrows where high dams could be built with secure foundations; and furthermore, it does not appear that objectionable silting would occur, since erosion in the valley is not excessive. With the exception of limestone there are few minerals of value that would be flooded, there being no coals of economic importance along the immediate valley. An obvious, and perhaps prohibitive, disadvantage would be encountered in the main-line tracks of the Chesapeake and Ohio Railway which closely follow the river from Bellepoint to Caldwell, Greenbrier County, and by the Greenbrier Division of this road which extends from Ronceverte to the head of the river. These tracks, with the exception of a short stretch near Big Bend tunnel in Summers County, usually vary from 15 to 30 feet above the river so that high dams could not be built without immense expenditures for the relocation of the tracks. There are also many towns and villages, together with good farming lands and highways which would be flooded; and from Riffe, Summers County, to the mouth of Second Creek, Greenbrier County, the river channel is mainly in the cavernous limestones of the Greenbrier Series, making it uncertain whether the waters could be successfully impounded.

Bluestone River.—The drainage basin of Bluestone River, tributary to New River at True, Summers County, has been described, pages 101-103, together with references to stream gages which were maintained for several years at Lilly and Barker's Ford and which have been published in various Water-Supply Papers of the United States Geological Survey. Tables of precipitation at Bluefield, Mercer County, on an upper tributary, and at Hinton, Summers County, a few miles below the mouth will be found on pages 26 and 49, respectively, of this Report.

From Rock, Mercer County, to the mouth at True, Summers County, this river flows through a thinly populated region for about 40 miles, there being a fall of about 825 feet in this distance.

In this entire length there are no railroads, except between Kegley and Rock where the tracks of the Virginian Railway

have a high alignment that would not interfere with any development so planned as to avoid flooding the railroads, towns, and other culture above Rock. From Rock down to Eads Mill the valley is fairly wide and the adjacent topography rather gentle so that some good land would be flooded in the immediate valley and along tributaries, and sites for dams would not be very good. Below Eads Mill the valley narrows to a gorge and so continues with few interruptions to the mouth of the river. Obviously the greatest amount of water could be impounded by building a dam near the head of the gorge at Eads Mill and flooding the sluggish valley and tributary streams upward toward Rock. In the lower valley, below Eads Mill, less valuable farming land would be flooded but a smaller amount of water would be held by a dam of the same height, owing to the steeper profile of the stream and to the narrower drainage channels.

In all the distance between Rock and True there are no coals or other minerals of appreciable economic value and there are no limestones that would introduce the hazardous element of subterranean flow, since the Avis Limestone, which crosses the valley a mile or two below Eads Mill is apparently not cavernous and in any case has no outcrop to the westward in the only direction in which water could flow through it. All things considered, Bluestone River offers a very favorable opportunity for power development.

East River.—The drainage basin of East River, tributary to New River at Glenlyn, Virginia, has been described, pages 109-111. No record of its run-off has been kept but precipitation figures are afforded at Bluefield, near its head, as published on page 26. For most of its length this comparatively small river is traversed by the main-line tracks of the Norfolk and Western Railway, the grade varying from 15 to 50 feet above water-level, and for a few miles along its lower course the Virginian Railway also follows the valley although at a considerably higher level. Along the comparatively narrow valley there are several villages of considerable size and much of the land along the main stream, as well as on its tributaries, is farmed. The limestones of the Greenbrier Series, overturned and now dipping southward at angles varying from 25

to 60 degrees, outcrop along the major portion of the valley, the alignment of the river being largely with the strike of the rocks, so that the uncertainty of possible subterranean drainage or seepage is present at nearly all localities. On account of all these unfavorable factors it does not appear that East River should be regarded with favor for any water-power proect of major importance.

Second Creek.—Second Creek, which is tributary to Greenbrier River a few miles below Ronceverte, Greenbrier County, but which lies largely in Monroe County, as already indicated in the description of its drainage basin, pages 100-101, has some favorable features that warrant attention from the standpoint of power development. Near its mouth it passes into the outcrop of the Greenbrier Series and its channel is subterranean but north of Hokes Mill the rise of the rocks toward the Sinks Grove Anticline brings to the surface the Maccrady and Pocono Series and these make it a narrow valley for three or four miles, or nearly up to Patton. In this portion of its course the topography is also favorable and a dam 50 feet high could be built without danger of much loss on account of seepage through caverns.

Between Patton and Second Creek village the limestones of the Greenbrier Series form the valley and are probably cavernous but above the latter village the Maccrady and Pocono again come to the surface and make the outcrop all the way to Red Mill, the valley being thinly settled and having narrows where dams could be built without excessive cost and with almost any desired height, since the fall between Second Creek village and Red Mill is more than 400 feet.

INDICATED HORSE-POWER OF STREAMS.

The following table, showing indicated horse-power developed by streams flowing through Mercer, Monroe, and Summers Counties, is compiled from Tables 2, 3, 4, and 10, pages 399-412, of the Semi-Centennial History of West Virginia by Dr. J. M. Callahan, the tables in question being part of a special article on "Water-Power Resources" by A. H. Horton, District Engineer, Water-Resources Branch, United

States Geological Survey. From the original tables there have been eliminated all tributary streams and sections of the main rivers which are not principally in the three counties, but sections which come partly within and partly without the county boundaries are included, the effort being made to set forth, as closely as the divisions of Mr. Horton permit, the water-power resources of the three counties:

Indicated Horse-Power Developed by Streams of Mercer, Monroe, and Summers Counties.

Stream.	Section. From	Section. To	Length. Miles.	Mean Drainage Area. Sq. Mi.	Minimum Discharge. Sec.-Ft.	Assumed Discharge for Maximum Development. Sec.-Ft.	Total Fall. Feet.	Minimum Horse-Power.	Assumed Maximum Development. Horse-Power.	Horse-power available from storage for 12 months.	Horse-power available from storage for 6 months.	Horse-power available from storage for 3 months.
New River.....	Below Island Creek....	Above Greenbrier River.	20	4,220	1,990	3,810	77	14,000	26,000	.....	.....	.....
New River.....	Below Greenbrier River..	1,200-ft. Contour (below Terry, Raleigh County)	20	6,300	2,140	5,000	182	35,900	84,000	3,480	6,960	13,920
Totals								49,900	110,000			
East River.....	Source	Mouth	24	79	17	50	1,100	430	1,260	.....	.....	.....
Indian Creek.....	Source	Mouth	34	180	40	113	1,000	920	2,600	.....	.....	.....
Totals								1,350	3,860			
Bluestone River..	Source	Below Mill Creek.....	23	111	33	56	1,100	836	1,420	.....	.....	.....
Bluestone River..	Below Mill Creek.....	Above Brush Creek....	50	196	38	88	560	2,010	4,530	.....	.....	.....
Bluestone River..	Below Brush Creek....	Mouth	11	405	35	146	450	1,450	6,040	.....	.....	.....
Brush Creek...	Source	Mouth	22	69	5.9	25	.....	136	575	.....	.....	.....
Totals							2,110	4,432	12,565			
Greenbrier River..	Second Creek.....	Mouth	36	1,460	133	590	260	3,180	14,100	34,400	68,800	137,600
Second Creek..	Source	Mouth	24	120	20	48	1,500	690	1,660			
Totals								3,870	15,760			
Grand Totals.								59,552	142,185	37,880	75,760	151,520

MINERAL WATERS.

GENERAL STATEMENT, MINERAL WATERS.

Within the three counties under study there are many localities in which mineralized waters exist in some quantity. The known occurrences are mainly springs which generally, though not always, are found in the regions of outcropping limestones but there are instances of such waters being found in drilled wells, the information on subterranean reservoirs being quite scanty because only a few wells have been drilled.

In most of the springs there is some form of sulphur which often discolors the basins so that various descriptive adjectives, based on these differences, have been locally applied and have come into general use as their most practical designation. Various other salts, including those of sodium, magnesium, and calcium, are usually present, and in a few instances iodine has been found.

These waters have been principally used as medicinal agents for the alleviation or cure of chronic diseases of the bodily organs or for the correction of various functional disorders, internal treatment being accomplished by drinking and external application being effected through the medium of baths. In addition to the use at local resorts large quantities of water are shipped away by some of the springs.

Table salt has been manufactured from the brines of one well but this industry was discontinued many years ago. So far as known, there has been no other attempt to utilize the waters for chemical or industrial purposes.

MINERAL SPRINGS.

MINERAL SPRINGS, MERCER COUNTY.

Mercer Healing Springs.—Mercer Healing Springs, located on Beaver Branch of Brush Creek two miles southwest of Athens, consists of slightly sulphurous and chalybeate water issuing from the Hinton Group of the Mauch Chunk Series, the elevation of the ground being 2,400′ B., or approxi-

mately 200 feet above the base of the Avis Limestone. The outcrop would be near the Tallery Coal horizon which might account for the presence of the sulphur although little or no actual coal may be present. These springs were formerly operated as a resort but at a recent date the hotel was destroyed by fire.

MINERAL SPRINGS, MONROE COUNTY.

Gray Sulphur Spring.—Gray Sulphur Spring, located in the south side of Scott Branch of Rich Creek 0.8 mile southeast of Peterstown and therefore in the edge of Giles County, Virginia, a few feet from the Monroe County line, is a stream of sulphurous water coming from the overturned and highly tilted lower portion of the Bluefield Group of the Mauch Chunk Series at elevation 1,670′ B. The name is derived from the gray deposit which clings to the concrete basin of the spring. Aside from this basin there is no other present evidence of commercialization, although it was exploited in former years according to local report. Even now the water of this spring is easily available, since a State road passes within a few rods of it and comfortable hotel accommodations are afforded at Peterstown. The property is now owned by C. P. Spangler.

Crimson Springs.—Crimson Springs, located on the waters of Turkey Creek one-half mile southeast of McGlone at an elevation slightly above 2,250′ B., come from the ground near the St. Clair Fault along which the White Medina Sandstone of Silurian age is in contact with the overthrust Beekmantown Limestone (dolomite) of the Ordovician, while just to the northward the ferruginous Clinton and Oriskany closely follow. The presence of mineral water at such a locality is not surprising, the red color being probably derived from iron leached by sulphurous currents from the adjacent beds. This spring has not been exploited as a resort, its position being far removed from railroads, hard roads, or hotel accommodations.

Old Sweet Springs.—Old Sweet Springs, located at Sweet Springs village in the valley of Sweet Springs Creek in the extreme eastern edge of Monroe County, at elevation 2025′ B., is one of the oldest resorts of its kind in the southern Appa-

lachians. From various records it appears that a grant from George III conveyed the property to William Lewis who established his residence on it in 1782, his actual occupation of the land being subsequent to the earlier cabin of James Moss who came there about 1760 and whose claims were acquired by Lewis before obtaining title in 1774. In 1792 a hotel was built by Lewis and the place at once became a noted resort. In 1830-1833 a much larger hotel was built and in 1857 cottages were added.

At the present time the plant includes the large hotel, now nearly 100 years old but still quite comfortable, numerous cottages, a bathing pavilion, and other buildings, and a golf course and other outdoor amusements, connection being afforded with the main line of the Chesapeake and Ohio Railway at Alleghany Station, ten miles from Sweet Springs, by automobile road. Situated in a gentle valley at the northern base of Peters Mountain and accessible by country roads to many other scenes of interest the place has an atmosphere of rare charm.

The springs issue from the Stones River Limestone of Ordovician age which is a prolific source of mineral waters owing to the ease with which it disintegrates under stream action. In the folder issued by C. H. Paxton, present proprietor, the following statements are made, together with an analysis by Professor Rogers:

"Among the varieties of drinking waters, that of the Main Spring (Chalybeate) has been celebrated from the time of the Indians for the cure of numerous chronic maladies, including kidney and heart trouble, gout, skin diseases, all rheumatic, neuralgic and arthritic affections, obesity, and especially the various conditions of nervous and physical exhaustion associated with dyspepsia, torpidity of the liver and the thinned blood of the anaemic. Dandruff, an annoying and almost universal affection, is quickly and effectually cured.

"The large pools, fed naturally by numberless mineral springs in the bottom, remaining at a temperature of 78 degrees the entire year, have long been famous for their health-giving and invigorating properties. The flow from the springs in these pools is enormous, thus insuring constantly changing waters."

"Analysis by Professor Rogers:

"1st. Solid matter procured by evaporation from 100 cubic inches 32.67

"2nd. Quantity of each solid ingredient estimated as perfectly free from water, 100 cubic inches—

Sulphate of Lime	5.703
Sulphate of Magnesia	4.967
Sulphate of Soda	2.746
Carbonate of Lime	13.013
Carbonate of Magnesia	0.357
Chloride of Sodium	0.060
Chloride of Magnesia	0.156
Chloride of Calcium	0.065
Peroxide of Iron (Sesquioxide)	0.065
Silica	0.075
Earthy Phosphate	a trace
Iodine	a trace

"3rd. Volume of each of the gases contained in a free state, in 100 cubic inches of water—

Carbonic Acid	37.17
Nitrogen	1.8
Sulphuretted Hydrogen	a trace
Oxygen	a trace

4th. Composition of 100 cubic inches of the mixed gases arising in bubbles in the spring—

Nitrogen	71.7
Carbonic Acid	28.3

"Temperature of the spring and bath, 78 degrees."

Roxalia Spring.—Roxalia Spring, located at Roxalia in the gap between Little Devil and Back Creeks near elevation 2549′ L., and in the narrow valley eroded between Middle and Gap Mountains, is a fountain of ferruginous (chalybeate) water that has been exploited in a small way by its owner, Arthur Wickline, there being a spring-house and boarding accommodations. The outcropping beds are the sandy shales and thin sandstones of the Portage Series which there dip northward at an angle of 70 degrees. The of flow water is small, there being a yellow sediment deposited on the spring basin.

Salt Sulphur Springs.—Salt Sulphur Springs, located on Indian Creek two miles southwest of Union near elevation 1802′ L., is an old resort which was opened to the public as early as 1823. In the years prior to the Civil War it was well patronized, particularly by southern guests, but after the war this custom was mostly lost and at the present time the hotel is not in operation although the old stone building still stands. The decline of this old property was doubtless

largely due to its isolation from railroads and good roads but the State road which passes across Monroe County is now partly completed and it would appear that rehabilitation of the resort would now be possible.

The springs, of which there are several, issue from the bottom of the creek valley at or near the base of the Alderson Limestone member of the Greenbrier Series and are variously described as containing salt sulphur, sweet sulphur, iodine, and as chalybeate. Perhaps the most interesting of these properties is the iodine which is now recognized as useful in the treatment of goiter but which is quite rare at inland springs.

Hunter Springs.—Hunter Springs, located on Indian Creek about two miles southeast of and above Greenville, are mentioned in various publications as containing mineral water but the character is not described. In this locality the limestones of the Greenbrier Series outcrop, much the same as at Salt Sulphur Springs, and dip in the same direction. So far as known there has not been much use of this water for medic inal purposes.

Lerew Springs.—Lerew Springs, located on Hands Creek and reported as containing sulphur waters, appear to have been used to some small extent but no statement as to their curative properties is available.

Red Sulphur Springs.—Red Sulphur Springs, located on Fitz Run of Indian Creek just south of Red Sulphur Springs village near elevation 1532′ L., derive their water from near the middle portion of the Bluefield Group of the Mauch Chunk Series and not far above the Raines Corner Limestone which outcrops at the village. The commercial use of this water was begun about 100 years ago, there being different reports as to the initial opening of the resort. A very good description of the place is afforded by Oren F. Morton in his History of Monroe County, as follows:

"Red Sulphur Springs lies in a deep hollow, near the mouth of a small tributary of Indian Creek and 12 miles from Lowell, its principal though not its nearest railroad point. The elevation is 1600 feet. The waters, which have a temperature of 54 degrees, derive their name from a peculiar sulphur compound which is held in solution. It is separated in the form of a jelly by atmospheric air and

also by acids. Mixed with a small quantity of common water and raised to a temperature of 80 degrees, this compound decomposes and gives off a powerful odor. But the spring water itself is colorless and transparent.

"These waters have long been known to have a quieting effect on the circulatory and nervous systems, reducing the pulse and promoting sleep. In catarrh, diabetes, chronic diarrhoea, and other affections of the secretory organs, and in functional derangements of the heart and liver, they have been used with great success. But their greatest repute is in the treatment of pulmonary consumption. The water appears to combat the 'great white plague' by building up the system and enabling nature to rid itself of the germ that causes the disease."

MINERAL SPRINGS, SUMMERS COUNTY.

Green Sulphur Springs.—Green Sulphur Springs, located on Lick Creek near the mouth of Mill Creek and near Green Sulphur Springs village slightly above elevation 1549′ L., consist of a drilled well on the Gwinn Estate, starting in the lower portion of the Hinton Group of the Mauch Chunk Series. Although situated only five or six miles from the Chesapeake and Ohio Railway at Sandstone and New Richmond, with which it is connected by a fairly good summer road, this water has been exploited but little, there being no large hotel although village accommodations are available. An analysis of this water is published as follows by James H. Miller in his "History of Summers County, West Virginia," page 746:

"Analysis of Green Sulphur Springs, the Property of Harrison Gwinn, Made by Booth, Garrett & Blair, Philadelphia.

This spring is sixty-five feet deep; bored in 1819.

	Grains per U. S. Gallon
Silica	0.711
Sulphuric Acid Radical	9.233
Bicarbonic Acid Radical	15.259
Carbonic Acid Radical	0.583
Phosphoric Acid Radical	trace
Chlorine	8.026
Iodine	0.012
Aluminum	0.015
Calcium	2.671
Magnesium	0.571
Potassium	0.076
Sodium	11.339
Lithium	0.015
Ammonium	0.009
Oxygen to form Al	0.013
Total	48.533"

Mention has already been made of the flow of salt sulphur water found in the **James H. Gwinn No. 1 well (11)**, drilled at the mouth of Lick Creek, the complete record being published in the Green Sulphur Springs Section, pages 239-242, with further comment on pages 660-1. In the first reference cited the statement is inadvertently made that the non-inflammable gas emanating from the well may be hydrogen sulphide. More probably this is nitrogen or carbonic acid gas or a mixture of these two.

Alum Springs.—On page 746 of Miller's History the following statement is made relative to the presence of Alum Springs:

> "There is a fine, cold alum spring on Elk Knob, on the Clark Grimmett place; also another on Beech Run, on the lands of John W. and Bent Barker, the waters of which are used for medicinal purposes."

Greenbrier Springs.—Greenbrier Springs, previously known as Bargers Springs, are located south of the Greenbrier River and southeast of the Big Bend, being about three miles south of Talcott Station on the Chesapeake and Ohio Railway with which they are connected by a good summer road and being also reached by automobile road from Hinton or Alderson. The spring issues from a calcareous zone in the Indian Mills Shale of the Bluefield Group of the Mauch Chunk Series at elevation 1460′ B., while the Raines Corner Limestone outcrops in the bed of the creek only a few hundred feet to the eastward and may be partly responsible for the mineralization of the waters, with which there is a considerable emanation of gas. The place is equipped with a hotel and several cottages and is surrounded with natural scenery of much charm.

According to Miller's History, pages 741-745, the property was first exploited by Isaac Carden, more than 100 years ago, but during the Civil War and for many years thereafter it was practically abandoned, being rehabilitated in 1903, with further additions in 1905 and 1906. In addition to much interesting historical data not herein pertinent Miller makes the following statement:

"These springs have been known as Carden's Springs, then Barger Springs, and renamed by the present owners as the Greenbrier Springs, the owners being a corporation under the West Virginia laws, known as the Greenbrier Springs Company. The water is recommended as a valuable cure for chronic kidney, liver and other complaints."

An analysis of this water, quoted by Miller, will be found on a later page.

Lindeman Springs.—Miller, in his History of Summers County, page 745, makes the following statement relative to Lindeman Springs, the exact location not being specified. Little Stony Creek comes into Greenbrier River from the south, one-half mile below and west of Greenbrier (Bargers) Springs:

"This is a fine sulphur spring on Little Stony Creek in this district, and is now owned by the Lindeman Estate, of New York City. It was purchased some twenty years ago by J. G. Lindeman, with sixty acres of land, from Dr. Eber W. Maddy for $2,000. No improvements have been made on the property, and it is practically lying to the commons. There is sixty acres of land lying around the spring, forming the springs property. The water is very similar to the Greenbrier Springs water."

Pence Springs.—Pence Springs, located on the north side of Greenbrier River one-half mile northeast of Pence Springs Station on the Chesapeake and Ohio Railway and near elevation 1521′ L., is one of the leading resorts of the Greenbrier Valley. The outcropping rocks at this locality are the limestones and calcareous shales of the lower part of the Bluefield Group of the Mauch Chunk Series, there being a rapid northwestern dip from the Alderson Anticline which exposes the top of the Greenbrier Series in the vicinity of Riffe. Miller, in his History of Summers County, pages 738-741, after describing in some detail the various ownerships of this property, makes the following statements which appear to contain most of the pertinent data:

"The farm was bought thirty years ago (probably about 1878—D. B. R.) by Andrew P. Pence, from the heirs of Jesse Beard. He began soon after its purchase to exploit the sulphur spring as a resort for persons afflicted with kidney, liver, dyspepsia and other afflictions, and by great persistence and energy he brought it up to one of the famous places in the State. Its curative properties have a wide repute throughout the Union.

"Analysis of Pence Springs, Made by Colonel M. B. Hardon, of Virginia Military Institute.

	Grains per U. S. gallon of 231 cubic inches:
Sodium Carbonate	14.568
Calcium Carbonate	1.312
Magnesium Carbonate	1.622
Strontium Carbonate	0.292
Lithium Carbonate	0.058
Ammonium Carbonate	0.009
Ferrous Carbonate	traces
Potassium Sulphate	0.052
Sodium Sulphate	0.682
Sodium Sulphide	0.426
Sodium Thiosulphate	0.402
Sodium Chloride	2.035
Sodium Iodide	0.002
Sodium Phosphate	traces
Borax	0.169
Alumina	0.407
Silica	0.554
	22.230
Carbon dioxide combined with carbonates to form bicarbonates	7.610
	29.840

	Milligrams per litre.	Grains per gal.
Ammonia	.016	.0009
Albuminoid Ammonia	.026	.0030

Cubic inches in the gases per gallon:	
Sulphuretted Hydrogen	0.15
Carbonic Acid	0.18
Nitrogen	4.09
Oxygen	0.17

Reduced to 60 deg. F. and 30 inches pressure.

"In recent years E. M. Carney, of Kanawha, purchased above Mr. Pence a tract of twenty-two acres of land, and began boring wells, of which he has completed three by this time, seeking for the famous sulphur water, and finally finding it, and which for the past few years he has been pumping in large quantities. He also erected a large hotel—'The Valley Heights Hotel'—and entertains a large number of guests, who come by reason of this sulphur water.

"The operations of Mr. Carney have resulted in two noted lawsuits—one in 1904, of Pence versus Carney, to enjoin the pumping and waste of the water. This suit was decided by Circuit Court Judge McWhorter adversely to Mr. Pence, who appealed to the Supreme Court of the State, where he reversed the lower court, but practically deciding that Carney had the right to pump the water in a reasonable way for beneficial purposes, but not for non-beneficial purposes or to waste it.

"Later, in 1907, Mr. Pence again sued out an injunction to stop what he claimed was a non-beneficial and waste of the water, which he contends has been done to his injury. The case has not yet been decided.

"It seems that when Carney pumps, the natural flow at Pence's ceases, and it then becomes necessary for him to place a pump and draw the water by powerful steam pumps. When Carney stops pumping for a few days, the water rises in Pence's Spring and flows as of old. As matters now stand, both parties are securing water by pumps, and neither has a natural flow. Mr. Pence does a large and profitable business in the bottling and shipping of the water, averaging some two hundred crates per week, at two dollars per crate, from which he has a profitable industry."

Analyses of Sulphur Waters.—Miller, on page 744 of his History, gives the following analyses of various sulphur waters of the Greenbrier Valley, the analyst not being named. It appears evident that the different localities have been abbreviated as follows:

Greenbrier ..... Greenbrier (Bargers) Springs, Summers County
Red ..... Red Sulphur Springs, Monroe County.
White ..... White Sulphur Springs, Greenbrier County.
Cold ..... Cold Sulphur Springs, Summers? County.
Blue ..... Blue Sulphur Springs, Greenbrier County.

Analyses of Various Sulphur Waters.—Miller.

Mineral Constituent.	Grains per U. S. Gallon.				
	Greenbrier.	Red.	White.	Cold.	Blue.
Sodium Carbonate.....	.....	.....	3.51	.....	.....
Calcium Carbonate....	11.53	5.25	1.17	1.84	5.05
Magnesium Carbonate.	8.16	4.81	.....	1.71	.94
Strontium Carbonate..	.....	.....	.....	.....	.....
Lithium Carbonate....	.....	.....	.....	.....	.....
Ammonium Carbonate.	.....	.....	.....	.....	.....
Ferrous Carbonate....	.....	.....	.....	.02	.....
Potassium Sulphate...	.....	.....	.....	.....	.....
Sodium Sulphate.....	15.89	4.14	9.35	2.46	16.22
Calcium Sulphate.....	5.71	.55	73.19	2.91	46.55
Magnesium Sulphate..	.....	.....	19.03	.29	6.38
Sodium Chloride.....	1.01	.....	.52	.12	4.21
Calcium Chloride.....	.....	.....	.02	.....	.....
Magnesium Chloride..	.....	.....	.16	.....	.....
Sodium Iodide.....	.....	.....	.....	.....	.....
Iron Oxide.....	.....	.....	.15	.....	.03
Alumina	.05	.....	.02	.25	.....
Sodium Sulphide.....	.....	.....	.....	.....	.....
Sodium Thiosulphate..	.....	.....	.....	.....	.....
Sodium Phosphate.....	.....	.....	trace	trace	.....
Borax	.....	.....	.....	.....	.....
Silica	1.25	.82	.....	1.48	.....
Organic Matter.....	trace	8.39	.01	.32	6.93
Ammonia	.....	.....	.....	.....	.....
Albuminoid Ammonia..	.....	.....	.....	.....	.....

Gases.	Cubic inches per gallon.				
	Greenbrier.	Red.	White.	Cold.	Blue.
Carbon Dioxide.....	18.84	5.75	8.49	.....	6.35
Sulphuretted Hydrogen.	.45	.40	.29	.....	.10
Nitrogen	.....	6.92	.....	.....	.....
Oxygen	.....	1.20	.....	.....	.....

Mercers Saltworks.—Mercers Saltworks were located on Lick Creek one-half mile above its junction with New River in the southern end of Summers County. As already mentioned, pages 663-4, the brine came from the **Jabez Anderson Salt Well (16),** drilled by Charles Clark and others about 1860 with a reported depth of about 1,100 feet. According to J. Anderson, present owner of the property and grandson of Jabez Anderson, salt brine was found at an unknown depth and was manufactured into salt for a time by Jabez Anderson but the plant was burned during the Civil War and was not rebuilt. The hole starts 30 or 40 feet below the Stony Gap Sandstone and is probably entirely in the Bluefield Group of the Mauch Chunk Series, since the reported depth would hardly make it reach the Greenbrier.

POSSIBLE SOURCES OF MINERAL WATERS.

From the great amount of mineralized waters, particularly those of the sulphurous and chalybeate types, issuing from the rocks in the three counties under study as well as in the neighboring counties of West Virginia and Virginia, it would appear probable that additional supplies would be found by drilling wells at various points. Presumably these compounds of sulphur and iron are derived mostly from the leaching of limestones and calcareous shales through which circulating meteoric water is occasionally able to find passage. If this be true it would seem best to drill in regions where the limestones have been considerably fractured or even faulted so as to afford initial passage of the water, and on structural slopes where there is a possibility of having artesian flow

by hydrostatic pressure along dipping beds. Such conditions occur at many localities in the three counties, as already described in the Chapters on Structure and Stratigraphy and as exhibited on Maps II, IV, and VI. Probably many failures will result from such drilling, however, since the presence of water in limestone formations can not be predicted with certainty and since its mineralization is even less certain.

Salt brine can probably be found in most of the synclines of the three counties where porous sandstones occur at depths of 1,000 feet or more, as was the case at Mercers Saltworks on the southern slope of the Hurricane Ridge Syncline. The actual depth to which fresh, meteoric water has penetrated in the rocks varies from place to place but there are few known localities in West Virginia where it is found as deep as 1,000 feet, hence the water in deeper wells is apt to be fossil, or connate, salt water held in the rocks since the time of their deposition. Not all of these deep rocks contain water, however, and its actual presence in a particular sand in a given basin or syncline can be proved only by prospecting.

Probably the most favorable regions for salt water in these counties are along the Hurricane Ridge Syncline in Mercer County and the edge of Summers and across Monroe; along the Bellepoint Syncline in Mercer and Summers; along the Springdale Syncline in northern Summers; and possibly in the Waiteville Syncline in Potts Valley of southern Monroe, although there may be a considerable penetration of fresh water in this latter basin owing to the outcrop of the sands at great height on Peters Mountain.

Even if brine is found in some of these basins its utilization will largely depend on its content of the salts of iodine and bromine rather than on the percentage of sodium chloride, since the latter occurs in such great quantities all over the world and transportation systems are now so perfect that its profitable extraction depends almost entirely on having a favorable low cost of production. On the other hand the growing demand for both iodine and bromine is causing an intensive search for water that contains them.

IRON ORE.

GENERAL STATEMENT, IRON ORE.

Iron ore in Mercer, Monroe, and Summers Counties is found mainly in the Oriskany Sandstone of Devonian age, and in the Clinton Series of the Silurian, the former being principally brown hematite (limonite) and the latter red hematite. In the Mississippian and Pennsylvanian nothing is found except occasional nodules of carbonate occurring at infrequent points in the shales and being too lean and irregular to be of value. The hematites are frequently colored almost black by a small amount of manganese but in most samples the amount of this element is too small for quantitative determination, although some instances of a true manganese ore were found, as will be later described.

The Oriskany and Clinton Ores are confined almost entirely to southern Monroe County, being too deeply buried for mining in Summers County and in nearly all of Mercer even if they are present at all. In the latter county, however, both the Oriskany and Clinton outcrop in South Bluefield east of the fair-grounds but the Oriskany appears to contain no ore and the Clinton is too lean and sandy and of too limited extent to be of value.

Interest in these ores is now dormant, owing to the richer and thicker deposits being exploited in the Great Lakes region, but they are a resource of much intrinsic value and the certainty of their eventual use requires their careful consideration.

PREVIOUS DEVELOPMENT, IRON ORE.

Crimson Springs Furnace.—In Monroe County a furnace was once operated on the McGlone Tract at Crimson Springs, one-half mile southeast of the present village of McGlone, but the operation ceased 70 to 80 years ago and the diggings are mostly filled with rubbish. No information of value is now available concerning the old plant but the ore was examined and sampled, as will be later described.

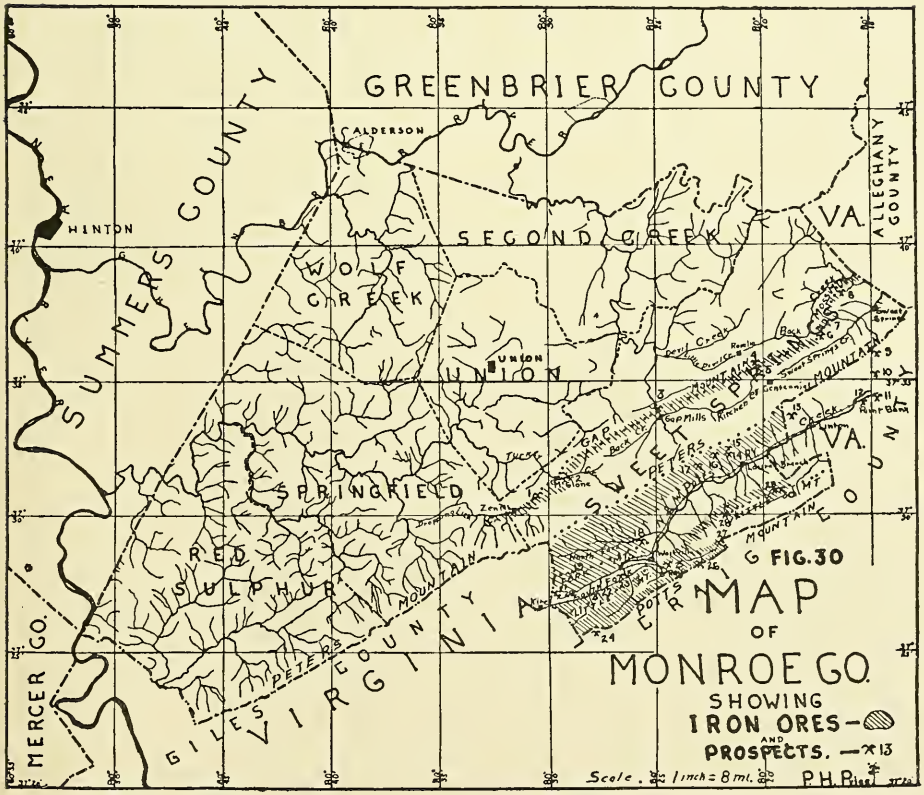
Paint Bank Mine.—On the south side of Potts Creek, Craig County, Virginia, about one mile east of and below Paint Bank, iron ore was once mined by the Virginia Iron, Coal and Coke Company on the land of the Potts Mining and Manufacturing Company, and a similar operation was conducted by the same parties along the railroad **Y** just east of Paint Bank. These workings began soon after the completion of the Potts Valley Branch of the Norfolk and Western Railway in 1909 but have been idle for several years. The product was washed at a local plant and then shipped to furnaces at Pulaski, Virginia, for reduction. A further discussion of this ore will be found on a later page.

IRON ORE PROSPECTS AND EXPOSURES, MONROE COUNTY.

In Monroe County, as shown by Figure 30, the iron ore outcrops and prospects are confined almost entirely to Gap Mountain in the east central portion, and to Potts Valley in the southern portion of the county. These ores occur partly in the Oriskany Sandstone and partly in the Clinton Series, which in this region are closely subjoined by disconformity, the intermediate series being entirely absent except for an occasional wedge of New Scotland Chert so that the ores from both formations often occur in the same pit, sometimes separated by a parting of chert or flint or possibly sandstone and shale, but often being in direct contact or else so much broken and mixed by faulting and folding that their separate correlation can not be easily effected.

In cases where the flint is present it affords a means of identification since the Oriskany ore belongs above it in the stratigraphic sequence while the Clinton ore lies below it, but when this is absent or obscured the age of the ore is nearly always in doubt since the hematite and limonite are often so mixed that their separate recognition becomes impossible and since the Oriskany Sandstone is often a white quartzite quite similar in appearance to those of the Clinton and the fossils in both, which in many regions are a certain guide, are usually obliterated by metamorphism.

Under such conditions these ores will be described primarily by geographic localities rather than by geologic formations, correlations being incidentally made when possible. On Figure 30 the various exposures and prospects are indicated by an appropriate symbol and serial number. These localities have been studied in part by the writer, with some assistance from Dr. Prouty, and in part by Dr. G. P. Grimsley who published his investigations in Volume IV of the Survey, pages 246-268 (1909), and included therewith numerous quotations from earlier students of the region. In the present Report the earlier work of these investigators will be freely used, since it is desirable to assemble the data.



Zenith Exposure (No. 1 on Figure 30).—In the vicinity of Zenith between Dropping Lick and Turkey Creeks, Dr. Grimsley in Volume IV, pages 255-256, gives the following description of iron ores:

"Zenith is located 2½ miles southeast of Crimson Springs. On the ridge, about half-way between the two places, are numerous nodules or boulders of an irregular brown hematite associated with flint fragments. The strata dip steeply southeast and trend N. 60° E. About one mile northeast of Zenith, a bed of brown iron ore was found 8 to 10 feet wide with a wall of white flint on the west and a pink flinty rock to the east. The bed trends N. 30° to 40° E. and apparently has the same relation to the other rocks as found in the furnace mine. The ore is a light brown hematite of good quality, according to the analysis.

"Over this ridge are numerous boulders of ore but no openings have been made, and similar boulders are reported from the slope of Little Mountain to the north of Zenith. There are indications of a considerable quantity of this ore probably in beds of good width, through the Crimson Springs and Zenith region, and its quality so far as developed at the present time is encouraging. However, it must be remembered that very little work has been done in opening the veins, and until such prospect work is made, it would be impossible to express any accurate opinion on quantity or quality of the ores."

The analysis of the sample collected by Dr. Grimsley, at the above locality, is published in the Table of Iron Ore Analyses at the end of this subject, there being a metallic iron content of 54.9 per cent. Dr. Grimsley does not correlate this ore but judging from the color it is probably in the Oriskany.

McGlone Tract Prospect (No. 2 on Figure 30).—Under the title of "Crimson Springs Mine" Dr. Grimsley describes as follows, on page 254 of Volume IV, the workings at the old furnace which was once in use on property now known as the McGlone Tract located near Crimson Springs one-half mile southeast of McGlone village:

"At this mine the ore is found in a mixture of flint and lime fragments, with shales below. It was worked in an open trench toward the north for about 20 feet on the side of the hill, and the ore can be traced a short distance up the ridge. The west wall is an irregular mixture of flint and iron standing as a solid face, four feet wide, while the east wall consists of white and blue flint dipping 80° west. The ore body is apparently 10 to 12 feet wide, and the west wall farther back is an irregular limestone breaking nodular, with strike N. 30° E. The ore is a brown hematite probably in or near the Lower Silurian limestone, and represents a replacement of the limestone, with the flint remaining. It is a light brown hematite or dark brown in some blocks, and shows considerable sand."

At the present time the old working is almost filled with rubbish but there is enough available evidence to show that the ore is principally in the Oriskany Sandstone and that some of it impregnates or adheres to the adjoining chert which is evidently New Scotland instead of "Lower Silurian" as surmised by Dr. Grimsley, there being fragments of **Spirifer** in the ore. West of the trench about 40 feet the black Marcellus Shale is visible, the ground between the trench and shale being covered with fragments of ore. East of the trench the Clinton Series and White Medina follow in regular succession there being a red ore at the top of the Clinton. According to Augustus Wickline, who worked in the Oriskany trench, the pay stratum increased in thickness with depth becoming 6 to 7 feet thick when the trench was 6 or 8 feet deep.

A sample collected by Dr. Grimsley at this working showed 47.44 per cent. of metallic iron as published on page 255 of Volume IV. The analysis of another sample (No. 607R), collected by the writer from fragments on the dump, is published in the Table of Iron Ore Analyses at the end of this subject, the metallic iron content being 40.3 per cent.

Iron Sandstone Exposure (No. 3 on Figure 30).—Passing northeastward from McGlone the Oriskany and Clinton Series are partly exposed in the gap of Second Creek just north of Gap Mills as indicated in the Gap Mills Section, page 230, but the ores of neither formation are clearly visible. At the base of the Clinton, however, lies the red and ferruginous Iron Sandstone with a thickness of 70 feet. At the request of the writer Mr. J. A. Kerr, United States Soil Surveyor, collected a sample from this sandstone, its composition being published in the Table of Iron Ore Analyses at the end of this subject. The metallic iron content is only 12.89 per cent., which is much too lean to permit its use as an ore especially with its siliceous base, but the ferruginous content of this ledge, which appears to extend from northeastern Pennsylvania to southern West Virginia and possibly farther and which often contains a considerable amount of iron, always has much interest.

Roxalia Springs Exposure (No. 4 on Figure 30).—On page 268 of Volume IV Dr. Grimsley describes as follows an ex-

posure that is evidently the Oriskany ore although he does not so name it:

"One mile back of the hotel at the Roxalia Springs located near the divide of the waters of Back Creek and Little Devil Creek, on the north slope of Gap Mountain, 340 feet above the level of the spring, an opening was made some years ago in a body of brown hematite. The ore body trends N. 20° to 30° E., and is opened over a width of 8 to 10 feet, with a thickness of 3½ feet near the outcrop. A section of this opening shows:

	Feet.
Yellowish white sandstone	3
Brown hematite ore	3½
Red sandstone	1
Blue and gray flint	8

"The ore is somewhat sandy near the wall, and has a dark brown color with a decided vitreous lustre, and is compact in texture with good weight."

The composition of a sample collected by Dr. Grimsley at the above locality is published in the Table of Iron Ore Analyses at the end of this subject.

Centennial Exposure (No. 5 on Figure 30).—On the top of Gap Mountain 1.1 miles northwest of Centennial at elevation 3160′ B., there is an exposure of ore which appears to belong in the Fossil Ore Horizon of the Clinton. Here the rocks are overturned and now dipping southward at an angle of 50 degrees. The ore is colored black with a trace of manganese and is associated with a red fossiliferous sandstone, and just to the southward it is buttressed by a hard white sandstone 15 feet thick. Dr. Grimsley, who also appears to have visited this locality, estimates the thickness of the ore as 4 to 8 feet. The analysis of a sample (No. 605R) collected by the writer is published in the Table of Iron Ore Analyses at the end of this subject.

Webster Goodykoontz Prospect (No. 6 on Figure 30) and John Owen Shaft (No. 7 on Figure 30).—These are more properly manganese ores and will be so described under the discussion of that subject on later pages.

H. C. Crowder Prospect (No. 8 on Figure 30).—The extreme eastern end of Gap Mountain is known as Moss Mountain and on it Dr. Grimsley describes, on pages 266-267 of Volume IV, the following prospect:

"The H. C. Crowder farm is located on the southern slope of Gap Mountain, over a mile back from the valley road and two miles northwest of Sweet Springs, in the eastern part of Monroe County. Boulders of brown hematite ore are very common on this land, and a large opening was made 100 feet long and 10 to 12 feet wide on the side of a hill or knob, shown in the photograph, Plate VII (of Volume IV).

"The length of the trench was supposed to represent the thickness of the ore body, but an examination of the trench shows the ore lies between two sandstone ledges which dip about 30 degrees east. The ore trends N. 60° E. and has a thickness of 6 to 8 feet. It was followed over the low hill for a distance of 200 feet across the bed, with a shallow cover of shales and sand and was opened by small pits. The same ore body was found across the small creek valley to the northeast where it has been exposed in two or three prospect holes. It is associated on this side of the creek or run with sandstone and flint nodules. A number of the hill slopes in this area show numerous loose boulders of ore and indicate a possibility of a considerable quantity of good brown hematite ore.

"The ore on the Crowder land is light brown in color with shaly fracture along black glistening planes."

The composition of the sample collected by Dr. Grimsley at this locality is published in the Table of Iron Ore Analyses at the end of this subject. Judging from the description it is probably the Oriskany ore.

Ocher Exposure (No. 9 on Figure 30).—On the southern slope of Peters Mountain in Craig County, Virginia, on the Sweet Springs-Paint Bank road 1.7 miles south of Sweet Springs, there is an exposure of red ocher at elevation 2770′ B. A considerable amount of this material is visible but it is mixed with soil and no estimate was made of its thickness and no sample was obtained.

W. H. Humphreys Exposure (No. 10 on Figure 30).—The W. H. Humphreys exposure located in Craig County, Virginia, in the public road on the southern slope of Peters Mountain 1.3 miles northeast of Paint Bank at elevation 2,250′ B. shows 5 feet or more of red or pinkish hematite coming between the quartzites of the Clinton Series and probably representing the Fossil Ore Horizon. A sample (No. 587R) was collected by Dr. Prouty and the writer, its composition being published in the Table of Iron Ore Analyses at the end of this subject. It is high in silica, however, the metallic iron content being only 17.02 per cent.

Paint Bank Mine (No. 11 on Figure 30).—At the Paint Bank Mine, located in Craig County, Virginia, in a ravine on

the south side of Potts Creek 0.7 mile east of Paint Bank at elevation 1,865′ B., a considerable amount of ore has been removed by the Virginia Iron, Coal and Coke Company, operating on the property of the Potts Mining and Manufacturing Company. As previously stated, the mining of ore began after the completion of the railroad in 1909 but the workings are now inactive. This ore was shipped to Pulaski, Virginia, for reduction but was first washed in a local plant at Paint Bank.

The ore was dug from two pits on either side of the ravine, being mostly limonite but mixed with red hematite and containing enough manganese to give some of the fragments a black color and also showing rather frequent incrustations of green copper ore. The rocks are bent upward in a very sharp anticline and are so broken and tumbled that the exact horizon of the ore, as well as its thickness, is a matter of some doubt, but it appears to occur principally in the Oriskany Sandstone into which it may be partly filtered. A few remnants of marine fossils are visible in the rock but according to Dr. Prouty, who visited the locality, they are too poor for recognition. Pockets of black Marcellus Shale are visible in some abundance in the cuts. A sample (No. 588R) was collected by Dr. Prouty and the writer, its composition being published in the Table of Iron Ore Analyses at the end of this subject.

Paint Bank Mine (No. 12 on Figure 30).—At the railroad Y on the same side of Potts Creek 0.2 mile east of Paint Bank and still in Craig County is a second working of the Virginia Iron, Coal and Coke Company on the property above described, its elevation being 1865′ B. Looking westward toward Paint Bank there is visible at the southern end of the pit a 5-foot bed of chert dipping southward at an angle of 60 degrees. Northward it is followed by 15 feet of loose sand, 10 feet of Oriskany Sandstone, 10 feet of chert, and then by the ore bed which is mixed with chert and which forms a perfectly preserved arch slightly overturned toward the north, being 25 feet wide at the base of the pit, and this thickness probably representing two limbs of the ore bed. Just to the north occurs a 10-foot thickness of Oriskany Sand-

stone. This ore was considered by Dr. Prouty and the writer as a bedded red hematite mixed with chert, being apparently in the Clinton Series and probably representing the Fossil Ore Horizon. The material is soft and ocherous in character. No sample was secured for analysis.

Rowan Prospect (No. 13 on Figure 30).—The Rowan Prospect, apparently located on the southern slope of Peters Mountain in the edge of Craig County, Virginia, slightly northwest of the present village of Linton, is described as follows by Dr. Grimsley in Volume IV, pages 260-261:

"This opening is in Virginia but less that a mile from the State line. It was visited by Dr. Ihne in 1894, who gives the following notes on this prospect. The opening is located on the slope of Peters Mountain, 300 feet above the valley. The Oriskany ore was uncovered over an area of over 100 square feet and to a depth of 2 feet where it appears as a solid mass of dense dark brown limonite visible above and below the opening and while incompletely opened gives indication of a very large deposit. The ore according to Dr. Ihne has the following composition:

	Per cent.
Metallic iron	59.10
Silica and insoluble	2.50
Metallic manganese	0.15
Phosphorus	0.40
Sulphur	Trace

Peters Mountain Exposures (Nos. 14 and 15 on Figure 30).—Two exposures on Peters Mountain located northward from Laurel Branch are described as follows by Dr. Grimsley in Volume IV, pages 262-263:

"While but few prospect openings have been made on this mountain, ore is found in loose blocks nearly its entire length in the Potts Creek area. To the north of Laurel P. O., about one and a half miles, on the mountain road 460 to 500 feet above Potts Creek, a bed of red hematite cuts across following a direction N. 20° to 30° E. It is exposed over a width of 10 to 14 feet, and its thickness is apparently 2 to 3 feet.

"To the east of the ore is a wall of hard white sandstone and above the ore to the top of the mountain is a series of red shales and red sandstone. The ore breaks in slabs and blocks and is bright red in color and represents the Clinton red hematite. In a second outcrop there is a heavy exposure of brown hematite mixed with a small quantity of red hematite. The ore has not been opened but the outcrop can be followed for some distance."

Dr. Grimsley collected a sample of the red hematite and of the limonite, these being republished in the Table of Iron Ore

Analyses at the end of this subject, under Nos. 14 and 15, respectively.

Mark Patton Exposure (No. 16 on Figure 30).—On page 263 of Volume IV Dr. Grimsley describes an exposure of ore that appears to be the Oriskany, as follows:

"The hill to the northeast of W. Mark Patton's house two and a half miles west of Laurel is thickly strewn with large blocks of brown hematite of good weight and quality. This ore was followed up the hill to the Oriskany Sandstone outcrop, where the blocks of ore are especially abundant.

"The ore has never been opened but from the number and character of the loose ore boulders, this is a promising tract for prospect work. The ore is dark brown in color with numerous black glistening areas. Some of the blocks show small globular or botryoidal surfaces composed of fibrous gothite iron."

The analysis of a sample collected by Dr. Grimsley on this tract is republished in the Table of Iron Ore Analyses at the end of this subject.

Bradley Prospect (No. 17 on Figure 30).—After mentioning a trench on the Jeter land in the valley 2 miles east of Waiteville where nothing of value was found, and an opening on the Arthur land on Peters Mountain north of the Jeter house where he records a show of 5 feet of Oriskany ore previously described by Mr. Gilmer, Dr. Grimsley continues as follows on page 264 of Volume IV:

"A little over a mile west of the Arthur is the Bradley prospect in the Oriskany brown hematite. This opening was visited by Mr. Gilmer when it was made. He describes it as a hard, brown ore of good quality, five feet thick and opened for 100 feet, with the following composition:

	Per cent.
Metallic iron	58.53
Silica	2.82
Metallic manganese	0.21
Phosphorus	0.44

Williams Prospect (No. 18 on Figure 30).—Near the eastern end of Fork Mountain Dr. Grimsley describes the following prospect on page 264 of Volume IV:

"On the North Fork of Potts Creek one mile north of Waiteville on Fork Mountain on the land of Henry Williams the Oriskany ore is found in loose blocks, but its thickness could not be determined. It was never opened to any extent, but from its position belongs at the

Oriskany horizon. Its composition according to analysis by Mr. Henry Froehling for Mr. Gilmer is as follows:

	Per cent.
Metallic iron	48.50
Silica	17.67
Metallic manganese	0.27
Phosphorus	1.02

Potts Valley Furnace and Mining Company Prospect (No. 19 on Figure 30).—On the southern slope of Fork Mountain 3.5 miles west of Waiteville and 0.6 mile east of the Giles County line the Fossil Ore Horizon of the Clinton outcrops over a considerable part of the upper slope, starting near elevation 3,280′ B., its northward rise being about the same as the topography. This ore is primarily red but contains enough manganese to color it black at some exposures. Its thickness is not visible but judging from the great amount of float a very considerable amount of ore should be found. A sample (No. 603R) was collected on the land of the Potts Valley Furnace and Mining Company at elevation 3,875′ B., the composition of which is published in the Table of Iron Ore Analyses at the end of this subject. This sample shows 47 per cent. of metallic iron.

Prospects Nos. 20 and 21 on Figure 30.—On pages 265-266 of Volume IV Dr. Grimsley notes the two following prospects:

"At the western line of Monroe County on South Fork of Potts Creek at an elevation of about 3,000 feet, two openings are described by Dr. Ihne, as follows, in his report of 1894:

" 'Several years ago an exploration hole of about 6 to 7 feet was made (**No. 20**), but which nearly half has been filled up again. This opening is located close to the wagon road at the low gap and at the watershed between the headwaters of Potts and Big Stony Creeks, and also close to the boundary of West Virginia and Virginia. At the left corner of this hole, stands on the wall an edged piece of fair, compact, brown iron ore 18 inches thick. * * *

" 'About 700 feet in a northwestern direction from the last described point, upward on the easy slope of the Peters (Fork?—D. B. R.) Mountain, the high crest of which is distant 1,000 to 2,000 feet, is another large opening (**No. 21**) in form of a trench of about 12 feet in length and 6 feet in width. * * * Besides the many boulders to be found, it seems also that a solid ore bank of from 4 to 6 feet thickness is in place there, but regarding the strike and dip of the vein, an accurate determination can not be made any more.' Dr. Ihne gives the following analysis of ore at the first opening (**No. 20**):

	Per cent.
Metallic iron	53.30
Silica	5.75
Metallic manganese	0.10
Phosphorus	0.50"

Potts Valley Furnace and Mining Company Exposure (No. 22 on Figure 30).—Along the Norfolk and Western Railway cuts east of the Giles County line the Oriskany ore is visible at various points, bedded in the massive sandstone. Just west of Harry Branch south of South Fork and 2.6 miles southwest of Waiteville at elevation 2,680′ B. in one of the cuts through the property of the Potts Valley Furnace and Mining Company it is six feet thick and bedded in loose weathered sandstone dipping northward 60 degrees and containing enough manganese to color it black. Here a sample (No. 602R) was collected, the composition of which is published in the Table of Iron Ore Analyses at the end of this subject.

Doss Prospect (No. 23 on Figure 30).—On pages 264-265 of Volume IV Dr. Grimsley notes the following prospect which is evidently the Oriskany ore:

"In the upper Potts Creek Valley on South Fork about four miles east of the western line of Monroe County is the store and post-office known as Waiteville, and about three miles to the southwest of this place are the ore openings on the Doss farm. The eastern opening shows a small body of ore apparently between flint on the west and the irregular brown Oriskany Sandstone on the east. This sandstone trends N. 60 degrees E. and dips to the northwest. The ore at the present time is not well exposed in this opening.

"The opening to the northwest shows the sandstone wall dipping to the northeast, and is 15 to 18 feet thick with 10 feet of ore in the hill above it. The ore has been opened in a trench 40 feet long and 15 feet wide. It is 100 feet above the road or at an elevation of 2,900 feet. The ore is light brown in color with the surface layers more or less open or honeycomb in texture. It contains small black velvet areas, also minute botryoidal surfaces. Its composition according to the analyses made by Henry Froehling for the Gilmer report and by Dr. Ihne is as follows:

	Froehling. Per cent.	Ihne. Per cent.	Ihne. Selected sample. Per cent.
Metallic iron	51.95	53.25	59.20
Silica	14.85	7.50	2.50
Metallic manganese	Trace	0.10	0.15
Phosphorus	0.59	0.65	0.60

Dr. Grimsley states that he collected a sample from an average lot of the ore. This analysis is republished in the Table of Iron Ore Analyses at the end of this subject.

Potts Valley Furnace and Mining Company Exposure (No. 24 on Figure 30).—In the Elliber Field, which is a clearing in the edge of Craig County, Virginia, just south of the summit of Potts Mountain and 3.9 miles southwest of Waiteville at elevation 3,635′ B., the float ore of the Fossil Ore Horizon of the Clinton is visible on the ground, its identification being possible because of the presence of the quartzite in the middle shales and the Iron Sandstone coming successively to the northward, the dip being southward at the rate of 40 degrees. A sample (No. 601R) was collected from this ore, which is colored dark by manganese, on the land of the Potts Valley Furnace and Mining Company, sometimes known as the Savage Tract, its composition being published in the Table of Iron Ore Analyses at the end of this subject.

Harry Shephard Prospect (No. 25 on Figure 30).—At the Harry Shephard Prospect, located on a low knob 0.6 mile northeast of Ray at elevation 2,580′ B., a digging was once made in the black Marcellus Shale which there covers the Ray Syncline but apparently not much ore was found. In the hill just to the northward, however, the Oriskany ore occurs in abundance on the surface rising northward to the top of the hill and the Back Valley Anticline and then dipping northward with the structure. This ore is colored nearly black, with a small amount of manganese. A sample (No. 599R) was collected from the float just north of the old prospect, the composition of which is published in the Table of Iron Ore Analyses at the end of this subject.

Potts Valley Furnace and Mining Company Prospect (No. 26 on Figure 30).—At the Potts Valley Furnace and Mining Company Prospect, located on the summit of Potts Mountain along the line between Monroe County and Craig County, Virginia, 1.3 miles eastward from Ray at elevation 3,215′ B., an excavation was once made in a reef of Clinton ore that appears to occupy a stratigraphic interval of 50 to 75

feet. Here the dip of the rocks is southward at an angle of 45 degrees. South of the prospect there are fragments of a white quartzite which is much more plainly visible a few hundred feet eastward along the ridge where it is 40 feet thick and forms the summit, being evidently the Keefer Sandstone and showing that the ore belongs at the Fossil Ore Horizon. At the south end of the prospect the ore is mostly red hematite with some incrustations of copper but northward it is colored black by manganese. Judging from appearances at the prospect as well as at outcrops along the mountain eastward there must be a large body of ore.

A sample (No. 600R) was collected from both types of the ore at the prospect, its composition being published in the Table of Iron Ore Analyses at the end of this subject. The sample shows 38.7 per cent. of metallic iron.

Potts Valley Furnace and Mining Company Exposure (No. 27 on Figure 30).—Three miles northeastward from Ray the ridge on which Prospect No. 26 is located ends abruptly but the name of Potts Mountain is continued with another bold ridge lying one-half mile farther to the north and formed by the Back Valley Anticline. On the southern side of this northern ridge in the edge of Monroe County 1.2 miles southwest of Arnold Knob and 2.7 miles northeast of Ray the float ore of the Fossil Ore Horizon is again visible at elevation 3,625′ B. and extends higher up the mountain. This exposure is colored black by manganese, being similar in appearance to the ore on the south limb of the mountain. No estimate of the thickness was obtained and no sample was taken.

Exposure No. 28 on Figure 30.—On a branch of Potts Creek on the northern slope of the Back Valley Anticline north of Little Mountain and 0.9 mile northwest of Arnold Knob, there is a considerable amount of float ore visible in the road at elevation 2,700′ B., the quality being fairly good as judged from its weight although no sample was taken. Local evidence is not available to show whether it belongs in the Oriskany or the Clinton.

Rutledge Ridge Prospect (No. 29 on Figure 30).—On pages 261-262 of Volume IV and under the heading of "Little

Mountain Clinton Ores" Dr. Grimsley gives the following deescription of the ores in Little Mountain:

"The ridge between Potts Mountain and the valley from opposite Laurel to the west with a length of 24 miles in Monroe County is known as Little Mountain and is divided by cross creek valleys into minor ridges which have received local names as Linton, Motisearge, and Rutledge Ridges and Kyers Mountain. They reach a height of 3,000 to 3,400 feet or 800 to 1,100 feet above the valley.

"The Clinton ore has been opened in a number of prospects along the line of these ridges, but these were shallow and are now nearly closed. In the prospects on Rutledge Ridge one mile back of Harvey Epling's house, or one and a half miles from the Potts Creek road and 700 feet higher, the ore is associated with a white flinty rock and red clay. The foot wall is a reddish sandstone with stringers of ore near its surface. This rock dips 60 degrees N. 40° W., and trends N. 45° E. The ore is a hard compact almost flinty ore with surface weathering to a yellowish brown. (For composition of Dr. Grimsley's sample see No. 29 in the Table of Iron Ore Analyses at the end of this subject.—D. B. R.)

"This ore is said to have a thickness of 2 to 5 feet, but it was not possible to make any measurements on account of the debris in these openings. The opening was in the form of a trench worked to the south, and to the north down the slope a number of pits or wells were opened some of which reached the ore body.

"This Clinton flinty ore was reported from a number of places along Little, or, as it is sometimes called, Middle Mountain, and the early reports on the area state it is continuous through this mountain. Mr. Gilmer in his report states that five openings between Linton's Run and Trout Run on Linton's Ridge, one opening on Motisearge Ridge and two on Rutledge Ridge, show 8 feet of ore on this mountain. He further says: This ore is as regular as a leaf in a book throughout this distance of six miles and can be seen nearly the whole distance varying in thickness from 3 to 10 feet, standing almost perpendicular, and exposed at an elevation of nearly 900 feet above the bed of the creek but cut in three places in this distance by streams flowing out of the back valley into Potts Creek. The ore will average 5 feet in thickness all this distance.'

"Mr. Gilmer gives the following analyses of these ores as made by Mr. Henry Froehling:

	Motisearge.	Linton Ridge.		
Metallic iron	50.22	45.92	52.09	51.80
Silica	15.34	21.20	12.74	13.02
Metallic manganese	0.14	0.10	0.11	0.10
Phosphorus	1.04	0.66	1.25	1.06

"Dr. Ihne in his report gives the following analyses of these ores:

	Linton Ridge.	Rutledge.
Metallic Iron	46.50	44.25
Metallic manganese	0.10	0.10
Silica and insoluble	16.30	25.50
Phosphorus	1.00	0.75

Wilbert Rutledge Exposure (No. 30 on Figure 30).—Just south of the summit of Little Mountain and evidently near the

portion of the ridge which has been mentioned by Dr. Grimsley as Rutledge Ridge there is an exposure of iron ore colored dark by manganese on the land of Wilbert Rutledge at elevation 3,150′ B., two miles southeast of Laurel Branch. Here the strata are overturned, the dip being southward at the rate of 41 degrees and the rocks being too much disturbed to gain an intelligent idea about their thickness. A sample (No. 589R) was collected from the float ore, its composition being published in the Table of Iron Ore Analyses at the end of this subject.

SUMMARY OF AVAILABLE IRON ORE.

The following table is an estimate of the amount of available iron ore in the Oriskany Sandstone and in the Fossil Ore Horizon of the Clinton Series. No figures are given for the Iron Sandstone of the Clinton, since its lean content of iron, and its objectionable silica base apparently make its utilization so remote as to remove it from serious consideration as an ore at the present time.

In computing the reserves of the Oriskany and the Fossil Ore Horizon their miles of outcrop have been measured on Map IV, this mileage being in some instances increased by considering as separate outcrops ore beds which may occupy both slopes of a mountain or anticline and may or may not be connected across the top, such exposures being, in general effect, double outcrops and more easily reduced to average width if separately considered.

Thicknesses of the ore beds and widths or depths of minable ore bodies, unlike lengths of outcrop, are matters of estimate only, the thicknesses being variable from place to place and often wholly concealed so that it has been necessary to judge them by the abundance or scarcity of float ore rather than by actual measurement. At some localities the ore bodies appear to be 10, 20, or even 50 feet thick with only a few included shale or sandstone strata but these have been regarded as pockets or lenses since the usual thickness is only a few feet while at other points it can be measured in inches.

The averages assumed are believed to be conservative although they are not capable of proof by actual figures.

The all-important question of mining width or depth, whichever it may be called, depends in part on the inclination of the strata containing the ore, which is variable but generally capable of reasonably certain determination, and in part on the origin of the ores. The Oriskany ore has been generally regarded as a replacement of calcareous strata, the iron being derived partly from the disintegration of the underlying Helderberg Limestone and partly from Devonian shales higher up and being gradually carried into leached zones of the Oriskany or deposited at its base by the action of percolating waters. In many regions this explanation appears to be satisfactory but in Potts Valley or Monroe County where Oriskany ore is abundant no Helderberg exists except occasional remnants of the New Scotland Chert and if a body of limestone sufficient to account for the Oriskany ore once existed at the Helderberg horizon its disappearance is now astonishingly complete. Farther north, in Gap Mountain, the Helderberg appears to be present at some localities and this theory of origin is more easily accepted. Without further speculation on the primary source of the Oriskany ore it most certainly occurs in well-defined layers within or parallel to the original Oriskany strata and it should probably be further regarded as metasomatic, its source and the actual time in which replacement occurred being in doubt. If replacement occurred reasonably soon after the deposition of the Oriskany the thickness and quality of the ore should not appreciably decline in basins where the sandstone container is now deeply buried but if this action has been comparatively recent the ferruginous content should decrease with depth and finally give out. In view of the uncertainty of this phase of the question it is regarded as more prudent to make estimates according to the theory of recent replacement without affirming actual belief in such a view.

On the Fossil Ore Horizon of the Clinton there is agreement, based on actual mining, that the iron content of the bed decreases with depth so that mining becomes unprofitable

a few hundred feet beneath the surface in regions where the strata are vertical or highly inclined; and there is further agreement, based on abundant observation, that this ore occurs in a well-defined bed parallel to the other Clinton strata and capable of being traced over wide areas by its stratigraphic associations and faunal contents. In basins where this bed is deeply buried it is usually calcareous and its iron content is too small for profitable mining but in localities where it lies on or near the surface the calcareous matter is greatly reduced if not entirely gone and the percentage of iron is often increased to an extent that makes it an ore. Dr. I. C. White, in his studies of this ore in northeastern Pennsylvania many years ago, reached the conclusion that the bed should most properly be regarded as a limestone in which surface enrichment had occurred, there being good evidence that such was the case in that region. Various writers on the Clinton ores of the southern Appalachian States, however, contend that the iron is principally connate and that the larger percentage of iron near the surface is accounted for by the disappearance of calcareous matter without an attendant influx of iron.

In Monroe County the Fossil Ore Horizon is soft, the adjective being used in its southern Appalachian sense of an ore which is devoid of lime rather than as an actual physical characteristic. There are no borings or other data available to show whether the bed becomes hard, or calcareous, when deeply buried, and therefore no positive evidence regarding the decrease in iron content. For the purposes of estimate it appears safer to make no allowance for deeply buried ore, simply because it is not proved that such deposits exist.

With the above factors in mind and with due regard to the dip, which in some slopes is only 15 to 25 degrees and elsewhere is 90 degrees or even overturned, estimates of minable widths or depths do not include any ore that may or may not exist more than 250 feet below the surface. If it should eventually be proved by drilling or mining that ore actually occurs in the Oriskany and Clinton in the Waiteville Syncline beneath the valley of Potts Creek and is not confined

to the mountain slopes where it is now in certain view, no harm will be done in omitting these speculative bodies from the present estimates, but on the other hand the inclusion of such wholly unknown areas is not justified by available data.

A further factor of some importance is the unit weight of the ores. From the Table of Analyses on a later page the average metallic iron content of 18 samples is 44.59 per cent., there being no wide difference between the average of the Oriskany and of the Fossil Ore Horizon. The weight of pure iron is 454 pounds per cubic foot and the weight of the sandy and shaly residue may be estimated as 150 pounds per cubic foot, so that the weight of a cubic foot of this ore, based on its average chemical content, becomes 285 pounds per cubic foot and it requires approximately seven cubic feet to weigh a short ton of 2,000 pounds.

According to the assumption and computations just enumerated the available ore from the two horizons is given in the table on page 769 arranged by mountain outcrops rather than by political units, since practically all of it lies within Sweet Springs District of Monroe County, there being an insignificant amount in Springfield District.

TABLE OF IRON ORE ANALYSES.

In the Table of Iron Ore Analyses, which follows the Summary of Available Iron Ore, the writer has assembled both the analyses of samples collected by himself and analyzed by Mr. Kaplan, present Chemist of the Survey, and the analyses of samples collected by Dr. G. P. Grimsley and analyzed by former Chief Chemist B. H. Hite and his assistants as previously published in Volume IV. In the tabulation of the two sets of analysis it will be noted that Mr. Kaplan made no determination of titanium or sulphur and that Mr. Hite made none of alumina. The samples, fortunately, are checkerboarded throughout the ferruginous belts so that little uncertainty should exist concerning these factors. In the samples of Volume IV manganese was reported in the form of dioxide (MnO_2), this being reduced in the present table to the proper

percentage of manganous oxide (MnO) to harmonize with the analyses of Mr. Kaplan which report it in the latter form. In the averages, No. 3, which is more properly a sandstone rather than an ore, and Nos. 6 and 7, which are from manganese prospects, have been excluded, their presence in this table being mainly for the sake of convenience.

Within the text on preceding pages certain other analyses, as previously quoted by Dr. Grimsley in Volume IV, have been published. It may quite well be possible that these samples were as carefully collected and analyzed as those in the official table but is regarded as more proper to present them separately.

Figure 30, page 751, shows the approximate locality of all prospects where samples were taken, further details being afforded in the descriptions, arranged by the numerical order of the prospects, on preceding pages.

Summary of Available Iron Ore, Monroe County.

Mountain.	Oriskany.					Clinton (Fossil Ore Horizon).					Total Ore. Short Tons.
	Miles of Outcrop.	Thickness Assumed. Feet.	Width or Depth Assumed. Feet.	Cubic Feet of Ore.	Short tons (2,000 lbs.) of Ore.	Miles of Outcrop.	Thickness Assumed. Feet.	Width or Depth Assumed. Feet.	Cubic Feet of Ore.	Short tons (2,000 lbs.) of Ore.	
Gap (including Moss)	19.6	4	300	124,185,600	17,740,800	13.2	4	300	83,635,200	11,947,885	29,688,685
Peters	10.0	4	1,000	211,200,000	30,171,428	11.2	3	1,000	177,408,000	25,344,000	55,515,428
Fork	5.2	4	500	55,112,000	7,873,143	5.0	5	1,000	132,000,000	18,857,143	26,730,286
Little (North of Potts)	15.3	5	500	201,960,000	28,851,428	10.0	5	400	105,600,000	15,085,714	4 3,937,142
Potts	13.5	4	400	114,048,000	16,392,571	21.3	6	500	56,232,000	8,033,143	24,425,714
Totals	63.6	..	.....	706,505,600	101,029,370	60.7	.....	.....	554,875,200	79,267,885	180,297,255

Table of Iron Ore Analyses.

No. on Figure 30.	Sample No.	Geologic Horizon and Name of Prospect.	Silica. (SiO_2)	Ferric Iron. (Fe_2O_3)	Alumina. (Al_2O_3)	Manganous Oxide. (MnO)	Lime. (CaO)	Magnesia. (MgO)	Titanium. (TiO_2)	Sulphur. (S)	Phosphoric Acid. (P_2O_5)	Moisture.	Loss on Ignition.	Total.	Metallic Iron.
1	.....	Oriskany? (Zenith)	9.22	77.29	.....	0.28	0.30	.....	0.11	0.03	0.16	0.80	8.78	96.94	54.09
2	608R	Oriskany (McGlone Tract)	22.40	63.38	5.48	trace	trace	.....	....	.....	0.75	.....	8.65	100.66	44.30
3	.....	Iron Sandstone (Gap Mills)	72.78	18.42	7.50	.....	0.05	.....	....	.....	trace	.....	1.40	100.15	12.89
4	.....	Oriskany (Roxalia Springs)	3.43	77.42	.....	0.014	0.30	.....	0.04	0.02	1.23	0.49	12.24	95.184	54.22
5	605R	Clinton—F. O. H. (Centennial)	26.90	56.20	8.91	trace	tracc	trace	....	.....	0.49	.....	6.70	99.20	39.30
6	608R	Oriskany? (W. Goodykoontz)	19.80	9.35	4.39	55.40 (a)	.....	.....	....	.....	0.22	.....	10.93	100.09	6.54
7	.....	Oriskany (John Owens)	13.29	5.19	.....	20.21 (b)	1.00	.....	0.11	0.02	0.22	0.28	11.26	51.59	3.64
8	.....	Oriskany? (H. C. Crowder)	18.52	64.40	.....	0.053	0.26	.....	0.18	0.02	1.26	0.17	11.47	96.533	49.56
10	587R	Clinton—F. O. H. (W. H. Humphreys)	58.08	24.32	13.12	.....	1.18	.....	....	.....	.....	0.26	3.43	100.39	17.02
11	588R	Oriskany? (Va. I. C. & C. Co.)	24.50	59.60	7.87	0.03	.....	.....	....	.....	0.40	0.73	7.50	100.63	41.90
14	.....	Clinton (Peters Mountain)	23.74	68.91	.....	0.032	0.21	.....	0.25	0.01	0.55	0.20	5.10	99.002	48.10
15	.....	Clinton? (Peters Mountain)	11.82	59.61	.....	0.04	0.36	.....	0.18	0.01	0.10	0.10	9.77	81.99	41.74
16	.....	Oriskany (Mark Patton)	5.84	74.02	.....	0.04	1.20	.....	0.14	0.02	1.01	0.08	10.52	92.87	53.20
19	603R	Clinton—F. O. H. (P. V. F. & M. Co.)	12.00	67.20	8.74	trace	trace	trace	....	.....	1.86	.....	10.49	100.29	47.00
22	602R	Oriskany (P. V. F. & M. Co.)	34.52	45.10	8.88	trace	trace	trace	....	.....	1.78	.....	9.20	99.48	31.55
23	.....	Oriskany (Doss)	10.43	73.54	.....	0.016	0.30	.....	0.07	0.02	1.06	0.23	11.85	97.516	51.38
24	601R	Clinton—F. O. H. (P. V. F. & M. Co.)	18.01	57.62	9.03	3.10	trace	tracc	....	.....	1.13	.....	10.80	99.69	40.61
25	.....	Oriskany (Harry Shephard)	9.44	70.60	7.59	trace	trace	trace	0.04	0.015	2.11	.....	9.91	99.705	49.38
26	600R	Clinton—F. O. H. (P. V. F. & M. Co.)	27.10	55.23	8.88	0.06	trace	trace	....	.....	1.54	.....	6.17	99.98	38.70
29	.....	Clinton (Rutledge Ridge)	11.67	74.37	.....	trace	0.21	.....	0.07	0.01	0.81	0.11	9.67	96.92	52.29
30	589R	Clinton (Wilbert Rutledge)	10.44	68.86	11.20	trace	trace	trace	....	.....	0.62	.....	9.00	100.12	48.20
		Average (c)	18.78	63.20	8.97	.....	.....	.....	0.12	0.017	0.99	0.32	8.96	.....	44.59

a. Metallic Manganese, 42.90.
b. Metallic Manganese, 17.02
c. Excluding Nos. 3, 6 and 7

MANGANESE.

GENERAL STATEMENT, MANGANESE.

Manganese, in fractional percentages, occurs generally in close association with the iron ores of the Oriskany Sandstone and Clinton Series in southern Monroe County. At many exposures the iron oxide is colored distinctly black and at some the deposits assume the botryoidal or radiate structure of psilomelane, leading often to the mistaken belief that valuable concentration has occurred. Perhaps small selected fragments might show a considerable percentage of manganese but generally the samples collected in a regular way from the surfaces of prospects or from several square yards of float ore reveal less than one per cent. of manganous oxide (MnO), mostly reported as a trace by the chemist. This condition appears to prevail generally in many of the iron ore exposures of Potts Valley, the ferruginous belts having been examined and traversed in considerable detail with the double purpose of searching for iron and manganese. It is quite possible, however, that some small deposits of commercial manganese may have escaped attention in this valley, since the region is almost entirely wooded and covered with much debris so that definite rejection of the area as wholly lacking in valuable concentrations of this ore would hardly be safe.

Stose and Miser[1], who have made a careful study of the adjacent territory of Virginia, conclude that the manganese deposits frequently occurring in that region at the Oriskany-Clinton contact have concentrated through the weathering of the rocks of this stage during an interval of exposure and erosion of the beds. Such a condition might easily have prevailed in Potts Valley, since practically all of the Helderberg Limestone of the Devonian is lacking and also the Salina and Niagara beds of the Silurian.

Farther north, in the range east of Gap Mills, known partly as Gap Mountain and partly as Moss Mountain, there

[1]G. W. Stose and H. D. Miser, Manganese Deposits of Western Virginia, Bull. XXIII, Va. Geol. Survey, pp. 52-55; 1922.

has been some hopeful concentration of manganese along the St. Clair Fault which splits the long axis of this mountain. These occurrences are found where the Beekmantown Limestone (dolomitic) is thrust over the Oriskany Sandstone, affording a favorable zone for the circulation of water so that enrichment may take place. The known prospects in this region are described below.

MANGANESE PROSPECTS AND EXPOSURES, MONROE COUNTY.

Webster Goodykoontz Prospect (No. 6 on Figure 30).— The Webster Goodykoontz Prospect, located on the summit of Moss Mountain 3.1 miles southwest of Sweet Springs and 1.2 miles northeast of Coakesbury Church at elevation 2,600'B., is a shaft six feet wide, six feet long, and 50 feet deep from which a quantity of manganese ore estimated at 65 tons has been taken and now lies on the ground. This ore is black and botryoidal, with a submetallic lustre, being too hard to be scratched with a knife but giving a brownish-black streak when scratched with a piece of sharp chert, and is evidently psilomelane, which is the most common ore of the region southward in Virginia. The concretions vary from a few inches to one foot in diameter and some of them contain softer interiors that may be wad or pyrolusite. A sample (No. 608R) collected from the stock pile is reported by Mr. Kaplan as containing 55.4 per cent. of manganous oxide (MnO), or 42.9 per cent. of metallic manganese, the full analysis being published in the Table of Iron Ore Analyses, page 770. According to Mr. Goodykoontz the ore may be followed southwestward along the summit of the ridge about 1½ miles to High Head Mountain, a prominent knob on Gap Mountain, and northeastward along the southern slope of Moss Mountain to its end which is two miles northeast of the prospect.

The Goodykoontz prospect was made in the St. Clair Fault which at that locality is near or only slightly south of the crest of the ridge. About 75 feet north of the prospect is a reef of Oriskany Sandstone, 30 feet thick and overturned,

the present dip being southward at an angle of 60 degrees. The exposure is much metamorphosed and no fossils are evident but it can easily be followed westward one-half mile to the private road which crosses the ridge where the black Marcellus Shale and other Devonian beds outcrop just northward in the direction of Back Creek, making the identification quite certain. Just south of the prospect the grayish-white chert of the Beekmantown Limestone, which is prominent along the whole southern face of Gap and Moss Mountains, litters the surface.

The St. Clair Fault has evidently furnished a convenient channel for the circulation of ground waters which have collected and segregated the ore from its original condition as disseminated particles, partly carbonates and partly oxides, existing both in the Beekmantown and in the Oriskany, the juxtaposition of these two formations on either side of the fault affording a most favorable zone for ore concentration.

Ore from this prospect could be trucked without much difficulty down the southern slope of the mountain to Sweet Springs Creek, the valley of which is 400 feet below the top of the ridge, and thence by a fairly good road and a water grade 13 miles to Alleghany Station on the Chesapeake and Ohio Railway. Such an arrangement would serve until the material could be fully tested in a practical way and until the ore deposit should be more fully proved, but it is also quite possible that limestone quarries could be developed along the valley of Sweet Springs Creek to help in supporting a branch railroad.

John Owen Prospect (No. 7 on Figure 30).—On pages 267-268 of Volume IV of the Survey Dr. Grimsley describes as follows another opening of manganese ore along the same ridge, the position of which does not appear to be far from the Goodykoontz prospect, and probably northeast of it, as judged from the sketch map in that volume, although the description is scarcely in harmony with the large scale topographic maps now available:

"On the John Owen land at the top of Gap (Moss?) Mountain, three miles west of the last prospect (Crowder—No. 8 on Figure 30), and a mile north of the valley road, a large amount of prospect work

has been carried on. A trench 290 feet long, 6 feet deep, was made in the red soil and flint gravel, showing small scattered pieces of iron ore. This main trench runs nearly east and west, and from it trenches were driven to the northwest 90 to 100 feet, which showed practically the same material as in the long trench.

"A square timbered shaft was made 50 or 60 feet deep to the east of the trenches, and is now half full of water, and no data could be obtained. From the dump at side of shaft, it is evident that near the bottom a lime and flint brecciated rock was found associated with nodular and botryoidal masses of a steel black ore probably manganese. The ore also forms a cement around flint fragments in some blocks. The nodules are ½ to 3 inches in diameter, hard but brittle, and composed of pipes of short columns rounded in outline. The level of the top of the shaft is 340 feet above the water in Back Creek, and no ore in quantity was found except in the shaft."

Dr. Grimsley collected a sample of the "steel gray ore", the composition of which is published under No. 7 in the Table of Iron Ore Analyses on page 770. This sample contained 24.8 per cent, of manganese dioxide (MnO_2), recomputed as 20.21 per cent. of manganous oxide (MnO), and representing 17.02 per cent. of metallic manganese.

The above prospect, from its description, appears to be in the same fault as the Goodykoontz and adds further information of value on the possibilities of commercial manganese along this ridge. The information now available, however, is not suffcient to justify a quantitative estimate of the ore but it is ground for belief that a series of diamond drill holes, preferably driven at a 45-degree angle through the fault and toward the Oriskany Sandstone, in the sector between High Head Mountain and the northeastern end of Moss Mountain, might reveal a valuable body of ore.

PRECIOUS METALS.

GENERAL STATEMENT, PRECIOUS METALS.

A study of the stratigraphic and structural evidence embraced in this report would doubtless convince the experienced geologist or mining engineer that precious metals, like gold, silver, copper, and lead, will not be found in appreciable quantities in the three counties. Throughout all the mountain regions of West Virginia, however, there exists a widespread belief, or at least a hope, that there is an abundance

of these materials, and expressions to the effect that the investigator who reports their apparent absence has failed to perform properly his appointed task or has dishonestly suppressed the truth, are not uncommon. Credence in such beliefs is often found in the more rugged parts of these counties, a common argument being to the effect that certain lands contain no coal and are unfit for cultivation and hence must have gold or other precious metals to preserve the equality of nature.

The factors which govern the accumulation of precious metals and the almost total absence of some of these essential conditions from West Virginia have already been mentioned by the writer in a previous volume[2]. Mercer, Monroe, and Summers are no exceptions to the general rule. All their rocks are of a sedimentary character without any trace of igneous or quartzitic intrusions with which these metals are commonly associated. There are no dikes or plugs and almost the only quartz is that which is contained in the pebbles of the conglomeratic sandstones and which has been derived from the destruction of mountain masses farther east, there being some beds in the southern edges of Mercer and Monroe where some of the ledges have been rendered more or less quartzitic by regional metamorphism without attendant intrusives. In some of the old mountains from which these sediments came there were probably mineral lodes but in the process of their destruction their ores have been broken up and dissipated so that in the regions where their disintegrated particles finally came to rest there are only traces of their former localized accumulations.

TRACES OF ORE.

In Springfield District, Monroe County, at a ravine on the eastern side of Rock Camp Creek 0.7 mile southeast of Rock Camp village and 0.1 mile southeast of **Fossil Lot 255 on Map IV** is located the **Joseph Harvey Gold Prospect** at elevation 1,885′ B. and only a few feet above the level

[2]David B. Reger, Tucker County Report, W. Va. Geol. Survey, pp. 429-430; 1923.

of the creek. According to Mr. Harvey this opening was made by Charleston parties about 1907 and was worked for two seasons, the ore having a reported value of 15 dollars per ton. The prospect is now partly filled up but it appears to have been made in a sandy zone of the Glenray Limestone of the Bluefield Group of the Mauch Chunk Series which is overturned and now dipping southeastward at an angle of 40 degrees. The material on the dump, examined by Mr. Price and the writer, shows a little quartz in fissures, the matrix being slightly altered by compression. A sample of the supposed concentrates, preserved by Mr. Harvey, showed inclusions of iron pyrites associated with quartz crystals without any visible evidence of gold.

In Second Creek District, Monroe County, at the **William Foster Prospect (No. 799 on Map IV)**, made by Mr. J. A. Folden on Carpenter Creek 1.3 miles east of Second Creek village, as previously described on page 517, some sort of white metal was reported as having been found but several blasts put off in the hole at the time of the writer's visit failed, unfortunately, to reveal any of the ore unless it was represented by some fragments of iron pyrites and copperas which occurred along with a thin streak of coal believed to be the Merrimac seam of the Pocono Series.

In Potts Valley there are occasional showings of copper along with the manganiferous iron ores of the Oriskany and Clinton Series. This is the case at the **Paint Bank Mine (No. 11 on Figure 30)**, located in Craig County, Virginia, on the south side of Potts Creek 0.7 mile east of Paint Bank. As previously described on pages 755-6, there are frequent incrustations of green copper ore associated with the iron.

At the **Potts Valley Furnace and Mining Company Prospect (No. 26 on Figure 30)**, located on the summit of Potts Mountain at the line between Monroe County and Craig County, Virginia, 1.3 miles eastward from Ray, the same evidence of copper is visible with the iron, as previously noted on page 762.

On the north side of Wilson Branch of Potts Creek, two miles northeastward from Ray and just north of the Ray

Syncline, the Oriskany Sandstone makes a reef in the topography at elevation 3,180′ B., with some associated float ore of iron, colored by manganese and having incrustations of copper ore, some of the material being mixed with fragments of New Scotland Chert.

In Greenbrier District, Summers County, the Coney Shale of the Bluefield Group of the Mauch Chunk Series, at its type locality in the cut of the Chesapeake and Ohio Railway at **Fossil Lot 244 on Map VI** just east of Avis, contains some inclusions of green, crystalline copper ore, as previously mentioned on pages 380-381. This interesting but wholly worthless deposit, so far as mining is concerned, appears to have resulted from the circulation of ground water through the sediments, the copper being leached from disseminated material and being recrystallized in the shale.

At the **John Redman Prospect (No. 777 on Map VI),** located on the north side of Indian Creek 0.6 mile southeast of Indian Mills, Forest Hill District, Summers County, previously described on page 400, and locally known as the **"Redman Gold Mine",** there are rather abundant iron pyrites crystals associated with a black, coaly shale at the horizon of the Red Sulphur Coal of the Bluefield Group of the Mauch Chunk. The occurrence of gold in any appreciable quantity in such associations would be too improbable for serious consideration.

A diligent search of the three counties would doubtless reveal many other instances where remnants of copper and possibly other precious metals have lodged in the stratified beds but the possibility of commercial segregation without attendant intrusions of quartz or igneous material is too remote to warrant that any expense be incurred in their further search.

FORESTS.

In Volume V of the State Survey Reports (1911) Mr. A. B. Brooks, former State Forester, has described briefly the forestry of the three counties, pages 198-200 being devoted to Mercer, pages 201-202 to Monroe, and pages 273-276 to

Summers County. The descriptions of present conditions and lumber mills are now somewhat obsolete but the account of original forests is of much interest.

ORIGINAL TIMBER CONDITIONS.

The account of original timber conditions in Mercer County by Mr. Brooks is as follows:

Original Timber Conditions, Mercer County.

"There is little left to show the character of the original forest of the southern half of the county. But, judging from the isolated areas of virgin forest still left, and from the statements of old residents in that section, it is certain that the region once abounded in the choicest of hardwoods. The limestone land, especially, in East River and Beaver Pond Districts, produced large numbers of excellent white oaks, yellow poplars and others usually associated with them. On the high crests of East River Mountain and on Stony and Red Oak Ridges, such timbers as chestnut oak, small white oak, basswood and pitch pine predominatetd. The softwoods of the southern half of the county were white and pitch pine and hemlock. These, however, have not grown there in large numbers.

"The northern half of the county has produced not only the hardwoods common to this section of the State but large quantities of softwood as well. Of the softwoods white pine and hemlock have been the chief valuable species. The white pine belt lies along the southeastern side of Bluestone River from a point about 2 miles above Spanishburg to near the mouth of the river in Summers County Northwestward from the Bluestone there is a scattered growth of white pine which joins the white pine area of Raleigh County. Below are given the approximate percentages of timbers growing on an 8,000-acre virgin tract in the white pine belt:

White Pine	60 per cent.
White Oak	25 per cent.
Hemlock	5 per cent.
Yellow Poplar	5 per cent.
Chestnut Hickory and others	5 per cent."

His account of original conditions in Monroe County is as follows:

Original Timber Conditions, Monroe County.

"The difference between the original tree growth of the mountains and that of the limestone uplands was as marked as the variation in the surface itself. The characteristic trees of the limestone areas were white oak, red oak, black oak, sugar maple, black walnut, shell-

bark hickory, wild cherry, poplar, basswood and cucumber; while those of the mountains which rise on the east were scrubby chestnut oak and pitch pine. Hardwoods grew exclusively on the northwestern faces of both Peters Mountain and Potts Mountain, but on their southeastern faces and on both sides of Gap Mountain, Middle Mountain and Cove Mountain softwoods, such as pitch pines and a few white and scrub pines, grew in pure stands or mixed with various species of hardwoods. Hemlocks and the pines once formed a fringe around the hardwood forests of the limestone lands, and grew in considerable abundance along Second Creek and other streams which descend to the Greenbrier and the New Rivers.

"A writer on the natural resources of West Virginia has said that 'Monroe was never a well-timbered county.' This is true so far as the mountainous sections were concerned; but an examination of a number of practically virgin wood-lots, scattered from Sinks Grove to Gap Mills, has shown that the statement would not have applied to the forests that once stood on the limestone areas. Mr. C. P. Lewis, the present County Surveyor of Monroe, for many years familiar with every section of the county, asserts that there was once a very fine stand of timber growing on the extensive and fertile uplands, and that there are still some single acres of virgin forest owned by the farmers from which 25,000 feet of white oak could be cut."

His account of original conditions in Summers County is as follows:

Former Timber Conditions, Summers County.

"According to Mr. J. C. James, a pioneer lumberman, the county was not as well timbered, originally, as some of the other interior counties of the State. It is fair to state, however, that prior to the beginning of any lumber operations, and before the area was visited by even the pioneer lumbermen, a large percentage of the rich land, where the best timber grew, had been cleared and the trees destroyed. Following are some of the timber trees mentioned by the older residents of Summers County:

White oak—The principal timber.
Chestnut oak—Common on dry ridges.
Poplar—Not generally abundant but good on Madam Creek and in some other localities.
Red oak—Common in rich ground.
Basswood—Common.
Buckeye—Common.
Walnut—Common.
Hickory—Common.
Ash—Common.
Cucumber—Not common.
Beech—Not common.
Birch—Not common.
Maples—Not common.
White pine—Small areas on Bluestone River.
Pitch pine—Occasionally seen on high ground.
Hemlock—Of good quality and common along streams."

PRESENT TIMBER CONDITIONS.

In Mercer County the original timber has now been removed and the present growth consists mainly of younger stock on land that has not yet been cleared. In the plateau region around Bluefield, Princeton, and Athens and eastward toward New River a large part of the land is cleared, there being occasional wood-lots and fringes of second growth timber along some of the rougher ridges and stream valleys. Farther south the crest of Stony Ridge and the rugged discontinuous ridges just south of East River are mostly covered with woodland of some sort and this is the case with the upper slope of East River Mountain at the southern edge of the county. In the valley of Bluestone River north of Spanishburg and along some of its western tributaries there is a greater percentage of forested land, although it has been only a comparatively few years since the Bluestone Valley in the northern part of the county was cut over by a mill operation located at Gardner. Farther southwest in the mining communities of Rock District the use of young timber equals or exceeds the rate of growth.

In Monroe County there is a wide area, extending from the villages of Nickells Mill, Patton, and Second Creek southward through the central limestone belt, from which most of the timber has been removed and only a few scattered woodlots remain. Along the northwestern part of the county from Alderson to Peterstown there is some timber but the smoother and more fertile ground, including the limestone land along the Alderson and Abbs Valley Anticlines and the plateau surface in the vicinity of Ballard, Cashmere, and Chestnut Hill, has mostly been cleared, leaving only the rough topography in woods. The northeastern corner of the county, east of Second Creek, is largely covered with second growth timber except in a few of the smoother valleys. Farther south a belt of cut-over woodland follows the summit and southern slope of Little Mountain almost entirely across the county, there being an open limestone valley just to the southward, the cleared areas of which extend half-way up the northern slope of Peters Mountain. On the crest of Peters

Mountain and in nearly all of Potts Valley farther south there are only occasional small areas of cleared land, most of the mountain and stream valleys having a thick growth of young hardwood timber which appears, most fortunately, to have escaped serious fires.

In Summers County the narrow stream valleys and lower slopes, as well as some of the broader ridges like Tallery Mountain and portions of Keeney Mountain and other northern ridges, have been largely cleared and put under cultivation leaving the upper slopes and many of the rougher ridges in timber which is mainly second growth. A few rough valleys like Pipestem Creek and Bluestone River south of Lilly and minor tributaries of New and Greenbrier Rivers are still uncleared, the timber being mostly second growth.

FOREST PROTECTION SERVICE.

Monroe and Summers Counties have no organized fire protection service. In Mercer the western edge is included in the Southern West Virginia Fire Protective Association embracing all or parts of Fayette, Kanawha, Raleigh, Boone, Mercer, McDowell, Logan, Lincoln, Mingo, and Wayne Counties. This association, of which Mr. E. C. Colcord of St. Albans, is President, was organized in 1916 and is composed of owners of forest land who by a voluntary assessment levied on a per acre basis contribute toward the protection of their land against fire and thereby cooperate with the Game and Fish Commission of West Virginia of which Mr. Fred E. Cowl, of Wheeling, is Chairman and Mr. A. B. Brooks, of Buckhannon, is Chief Game Protector, and with the United States Forest Service. Both of these latter organizations provide certain additional funds as well as expert advice and supervision.

According to present information, largely obtained from the report of the Association as of April 1, 1924, and the report of the Game and Fish Commission as of December 1, 1924, one lookout station is located at Pilot Knob on the Mercer-Wyoming County line about one mile southwest of Black,

and another is maintained on Flattop Mountain near the common corner of Mercer, McDowell, and Wyoming, while the District Ranger, Mr. J. W. Karr, has headquarters at Bluefield.

Although not yet actively organized for protective purposes the remainder of Mercer and all of Monroe and Summers belong under the administration of the Game and Fish Commission and further expert advice is afforded not only by the United States Forest Service but also by the Extension Department of the West Virginia University of which Mr. Thomas W. Skuce, of Morgantown, is Extension Forester.

LUMBER MILLS.

There are no large lumber mills in any of the three counties, the most prominent operation in the season of 1922 being the **L. O. Steinbeck Lumber Company** located at Secoma along the Sewell Valley Railroad on Meadow Creek, Summers County. This plant was reported as having a daily capacity of 25,000 feet, most of the timber being obtained from the southern edge of Fayette County.

Elsewhere in all three counties there are numerous small portable sawmills operating occasional patches of virgin forest or the more mature areas of second growth. Some of these mills are located many miles from the railroads and depend on heavy truck transportation to get their lumber to shipping points.

CHAPTER XVI.

CLAY, BUILDING STONE, ROAD MATERIAL, AND GLASS-SAND.

CLAYS AND CLAY INDUSTRY.

PRESENT DEVELOPMENT, CLAY INDUSTRY.

Although having a large amount of clay and shale suitable for the manufacture of brick and other clay products these materials have been only slightly exploited in Mercer, Monroe, and Summers Counties. At the present time no plants of this character are in operation.

In Mercer County there was once a brick plant on the northern side of Bluestone River along the Norfolk and Western Railway 0.8 mile southeast of Bluestone Junction. This concern obtained its shale from a red member of the Mauch Chunk Series which outcrops along the western slope of the Abbs Valley Anticline in that locality. No determination of the exact bed was made due to the fact that the writer's visit occurred before the detailed subdivision of the series had been effected. This plant was completely dismantled many years ago, no further information regarding it being available.

In the city limits of Bluefield a brick plant was once operated on the northern side of the Norfolk and Western Railway just east of the present quarry of the Baker Stone Company, 1.3 miles east of the station. This plant, which is the property of R. F. Baker, is still standing but is not in operation. Residual clay of a calcareous nature, obtained in a sink-hole on the outcrop of the Greenbrier Series, was used for making the brick but did not prove satisfactory.

AVAILABLE CLAY AND SHALE.

RESIDUAL CLAY.

Residual clay, which is derived from weathered rocks and shales and still remains at its original location, may be found at many points in all three counties and some of it could be used for making common building brick or drainage tile, but material of this sort often compares unfavorably with bedded deposits and is usually of more value for agricultural soil than for ceramic use. Probably the best of these deposits are to be found on the outcrops of the red shale members of the Mauch Chunk and Maccrady Series, the Chemung and Portage Series of the Devonian, the Red Medina Series of the Silurian, and the upper part of the Eden Group of the Martinsburg Series of the Ordovician, all of these outcrops being indicated on Maps II, IV, and VI. As a rule the clays derived from purely calcareous beds like the Greenbrier and the Stones River contain too much lime for successful use, although there are reported instances where weathering has been so complete that little lime now remains.

S. P. Wheeler Clay Exposure.—Mr. A. T. Wheeler of Princeton has made some experiments with residual clay on the land of S. P. Wheeler on a branch of Middleton Fork of Bluestone River 0.9 mile southwest of Lashmeet, Rock District, Mercer County, at elevation 2,520′ B. This clay is derived from the country rock, being near the contact of the Pocahontas Group of the Pottsville Series and the Bluestone Group of the Mauch Chunk Series. The material has accumulated along a ravine above the Wheeler residence, being quite soft and free from grit, yellowish-white, although containing a little iron, and having an apparent thickness of 10 feet but having only small lateral extent. A specimen of brick made from this material is light buff in color and has a generally good appearance. A sample (No. 635R), collected from the outcrop, has the following composition according to Mr. Kaplan:

	Per cent.
Silica (SiO_2)	80.00
Ferric Iron (Fe_2O_3)	1.78
Alumina (Al_2O_3)	13.06
Lime (CaO)	Trace
Loss on ignition	5.00
Total	99.84

From the above analysis the material appears to be mostly finely divided silica with barely enough alumina to make it plastic, although no determination of less refractory compounds except iron was made. These could not be large because of the small amount of matter that is unaccounted for. Owing to the amount of iron, brick made from this material would probably be ranked only as semirefractory and would likely be of more value for building purposes than for anything else. The lack of convenient railroad facilities and the limited amount of clay would make its exploitation a somewhat doubtful success.

TRANSPORTED CLAY.

Along the valley of New River at many points in Summers County there are extensive deposits of river clay many of which are derived principally from red shale and contain material that would be suitable for making brick or drainage tile, although the product would hardly compare with that which could be made from the outcropping shales themselves. The same statement might be made relative to the transported clays along the valleys of Greenbrier River in Summers and Monroe Counties, and of East River and the upper valley of Bluestone River in Mercer County except that the deposits along these streams are of much more limited extent. The most extensive beds of this character are noted as Alluvium on Maps II, IV, and VI.

STRATIFIED SHALES.

Stratified shales, composed principally of silica and alumina, with a variable content of ferric iron and other minor substances, and having the necessary plasticity for molding

into brick or tile shapes, occur in great abundance in all three counties. In the Bluestone and Hinton Groups and the upper part of the Bluefield Group of the Mauch Chunk Series, described in detail in Chapter VII and shown by outcrops on Maps II, IV, and VI, there is an enormous quantity of red shale that would make red building brick of pleasing appearance, building tile, or drainage tile. There is also a heavy bed of shale (Lillydale Shale) coming at the base of the Bluefield Group and outcropping in all three counties. The analysis of a sample (No. 636R) of this shale, collected from the fill of the Virginian Railway east of Hales Gap Tunnel, Mercer County, and published on page 442, shows a considerable loss on ignition probably due to included carbonaceous matter, and this, together with occasional lentils of limestone might make it objectionable for brick making.

In the Maccrady Series of the Mississippian there are abundant red shales which could easily be quarried and which should burn into good red building brick or tile. A sample (No. 625R) was collected from 35 feet of this shale, recorded as No. 6 in the Spider Den School Section, page 227, and located on the property of David Bland in the northern end of Monroe County along the road which descends into the valley of Second Creek 0.6 mile southeast of Hokes Mill at elevation 2,065′ B., its analysis being as follows, according to Mr. Kaplan:

	Per cent.
Silica (SiO_2)	52.48
Ferric Iron (Fe_2O_3)	8.40
Alumina (Al_2O_3)	28.80
Lime (CaO)	1.14
Magnesia (MgO)	2.88
Loss on ignition	6.70
Total	100.40

The above analysis shows material that would be suitable not only for making brick or tile but also for mixing with a comparatively high silica limestone in order to increase the relative proportion of alumina for a Portland cement mixture, since its content of alumina (28.8 per cent.) is unusually high. The presence of this shale just below the limestones of

the Greenbrier Series, some of which contain silica without much alumina, is worthy of attention.

In the Pocono Series of the Mississippian the shales are so generally associated with lenticular sandstones that their use in the ceramic industry would be attended with difficulty. The Sunbury Shale, however, coming near the base of the series, is practically free from sandy beds but it contains a large amount of carbonaceous matter that would cause much shrinkage in burning and hence would probably be undesirable.

In the Devonian Period the shales of the Chemung and Portage are interlaminated with many sandstone flags and would be troublesome or perhaps impossible to use in most cases while the black Marcellus Shale, farther down, contains much organic matter and would shrink in burning.

In the Silurian Period there are abundant shales in the Clinton Series, partly red and partly olive-green in color and containing ferruginous material and streaks of sandstone. These shales have been successfully used for making brick at Cumberland, Maryland, the product burning to a dull red or brown. By a careful selection of the more argillaceous exposures it would be possible to make a good grade of building brick from these shales. Most of the outcrops, however, are in the mountainous regions of southern Monroe County and distant both from good local markets and from trunk-line transportation.

The red shales of the Red Medina Series of the Silurian, outcropping principally along the northern slopes and near the tops of East River and Peters Mountains, might be made into brick at some localities, but generally they are so mixed with sandstones as to be unfit for consideration.

In the Martinsburg Series of the Ordovician there are abundant yellow shales, partly in the Lower Maysville and partly in the Eden Group, that have the appearance of good brick material in the localities where they are reasonably free from limestone as is generally the case along the northern slope of East River Mountain in southern Mercer County. No analysis of these shales was made. Farther down in the Ordovician and the top of the Cambrian there are no shales

of consequence, the strata being almost entirely calcareous.

In the vicinity of Bluefield material worth consideration for building brick, building tile, or drainage tile is to be found in the yellow shales of the Maysville and Eden Groups of the Martinsburg Series, occupying the northern slope of East River Mountain, as outcropped on Map II; in the red shales of the Maccrady Series, outcropping on the upper northern slope of the sharp ridge which divides Bluefield from South Bluefield; in the red beds of the upper part of the Bluefield Group of the Mauch Chunk Series, visible on the southern slope of Stony Ridge near the massive Stony Gap Sandstone which forms the central core of the ridge; in the abundant red shales of the Hinton Group, lying on the northern slope of Stony Ridge, being accessible to rail transportation along the trolley of the Princeton Power Company near Stony Gap and along the Norfolk and Western Railway about one-half mile northwest of the new station of Bluefield, Virginia (formerly Graham); and in the red beds of the Bluestone Group which outcrop along the Hurricane Ridge Syncline.

In the neighborhood of Princeton brick and tile materials can be obtained from the Bluestone Group outcropping in the hills just south of the city, as shown on Map II; and from the red beds of the Hinton Group, occurring in abundance northward toward the Abbs Valley Anticline and around Athens.

Near Peterstown there are abundant red shales in the Hinton Group and the upper part of the Bluefield, especially in the region westward toward the mouth of Rich Creek and along the Virginian Railway north of and below Rich Creek.

Around Union the outcrops are almost entirely limestone, the nearest suitable shales for brick and tile being along the Hurricane Ridge Syncline southwest of Turkey Creek or along the Dorr Syncline along Rayburn Draft. In view of the high cost of fuel in this interior region of Monroe County there is not much present incentive toward the utilization of these shales.

At Alderson the exposed beds are mainly calcareous, an exception being the black Lillydale Shale which is carbon-

aceous and would therefore be apt to shrink in burning. Material for brick or tile could be secured, however, in the outcrops of the Bluefield Group in the edge of Summers County west of Greenbrier River where the red shales are noticeable in the hills.

Around Hinton there are immense deposits of red shale in the Hinton Group, occupying the valley walls of New and Greenbrier Rivers. These shales would be quite suitable for brick and tile, there being heavy beds which are practically free from included sandstone and have a proper chemical character. On page 355 there is published an analysis of the Hackett Shale member from the land of the Hinton Water, Light and Supply Company along the Keeney Mountain road one-half mile east of Hinton; and on page 352 there is an analysis of the Lower Avis Shale member from the land of Wiley McGraw along the Tallery Mountain road south of True.

FIRE CLAY.

Fire clay, in its strict sense of refractory material capable of resisting high furnace temperatures, is not known to occur in quantity in the three counties. In the northwestern portions of Mercer and Summers, beneath the coal beds, there is often light-colored clay from which the iron has been leached by the vegetable growth which formed the coal, but these clays are otherwise impure and lacking in the qualities to be found in the true fire clays of northern West Virginia, Maryland, and Pennsylvania.

BUILDING STONE.

QUARRIES.

In Chapters VI-XII, inclusive, dealing with the stratigraphy of the rocks, the sandstone quarries of the three counties have been described, and in Chapter XIV, devoted to Limestone, the limestone quarries have been noted. Reference to any of these quarries may be had by consulting the Index

at the end of this Report where these items are listed under "Sandstone Quarries" and "Limestone Quarries", respectively, making further recapitulation unnecessary.

AVAILABLE STONE.

The sandstones of the three counties, as described in Part II of this Report, vary from flaggy and shaly beds that are not sufficiently durable to be used as building stone to great massive ledges, 50 to 150 feet in thickness, that will split into any desired size. In the Pottsville Series there are several coarse gray sandstones that afford local material of a durable nature in the mining towns of the western part of Mercer County and that will serve the same purpose in the coal areas of Summers when these are exploited. In the Mauch Chunk Series there are numerous sandstones of which many are shaly, flaggy, or otherwise unsuitable for building stone, and also several which are well adapted for such purposes both in the way of pleasing texture and durability. In the Greenbrier Series there are no sandstones worth mentioning in the local area and the limestones mostly have an irregular fracture that makes them difficult to use for buildings. In the Maccrady Series the few sandstones visible are shaly and friable, being totally unfit for construction purposes. In the Pocono Series the sandstones are much cross-bedded and contain frequent pockets or lentils of shale that make them generally indifferent as building stone at their outcrops in Mercer and Monroe, although there are localities where smoother and more acceptable stone can be secured.

In the Devonian Period the Chemung and Portage Series afford only flagstones and there are none of any description in the Genesee, Hamilton, and Marcellus, but the Oriskany is nearly always a massive rock. In southern Monroe County this is a durable and quartzitic ledge from which good stone could be quarried but the outcrops are in rough mountain areas where there is no local demand and where transportation is poor.

In the Silurian Period there are heavy sandstones in the Clinton Series, two of which are gray quartzites quite massive

and durable but difficult to split and impossible to dress into shapes, while the third is a red and ferruginous ledge of most pleasing texture for buildings but also too tough for successful masoning. Nearly all of these outcrops are in the thinly settled region of southern Monroe County. The White Medina Sandstone of the same period is a massive quartzite, like those of the Clinton, and would be troublesome to fashion into regular shapes. In the Red Medina the sandstones are too shaly and irregular to be of value.

In the Ordovician Period there are some friable and worthless sandstones in the Lower Maysville Group of the Martinsburg Series and farther down the rocks become calcareous with an irregular fracture that appears to preclude them from successful use as building stone.

On the following page, under the subject of "Road Material", will be found a table indicating the principal sandstone beds worthy of attention from a building standpoint, together with the necessary references to their detailed descriptions.

ROAD MATERIAL.

RIVER AND CREEK GRAVEL.

Attention has been called in many previous Reports of the Survey to the fact that most of the rivers and creeks of the State contain an abundant supply of gravel, which, being the more resistant portions of the rocks from which they came, afford good and cheap material for improving roads. These gravels can be used to advantage in the improvement of muddy sections of secondary roads where a hard surface may be too expensive, and they may also be used as the aggregate for concrete paving and structures.

CHERT.

Chert, when finely broken, affords good material for cheaply surfacing light traffic roads. In the Sinks Grove and Hillsdale Limestone members of the Greenbrier Series

there is abundant chert which forms a partial macadam in regions where the limestone matrix is weathered out and which also litters the fields, interfering with their cultivation. There are no natural deposits of this chert sufficiently large to be quarried for road building but in localities where these small chunks have been hauled from the fields their use on the roads would be an advantage. In the Beekmantown Limestone, also, there is a vast quantity of chert some of which weathers from the matrix into scoriaceous forms and some into large rectangular blocks but all of which is almost indestructible and must be removed from the fields before they can be successfully cultivated. Much of this chert now congests the roadside fence-rows in unsightly heaps, but by the use of portable crushers this refuse material could be reduced to convenient size for surfacing at an insignificant cost and thus utilized to advantage. At the Oriskany-Helderberg, or Oriskany-Clinton contact, as the case may be, there is often a zone of chert which could also be used on the roads.

SAND.

Sand, which is another essential material needed in road building, both in masonry construction and in concrete, is found generally along the rivers and creeks of the three counties, being derived in great abundance from many series of rocks from the Pottsville Series of the Pennsylvanian down to the White Medina Sandstone of the Silurian. These deposits are locally visible and need no elaborate description.

So far as observed there are no extensive sand beds of Pleistocene age in the numerous terraces of New and Greenbrier Rivers, this material being generally composed of a mixture of gravel, sand, silt, and soil that could hardly be used for building purposes.

Sand of a better quality for construction purposes than that found along the rivers could be obtained at a considerably higher cost by crushing it from sandstone ledges and in rare instances some of these have been weathered out so that quantities can be gathered from the outcrops. At the entrance to the Bluefield Fair-Grounds the Oriskany Sandstone, which

is partially disintegrated, has been quarried for building sand but this excavation has now reached the point where blasting and crushing is required. As shown by the Bluefield Fair-Grounds Section, page 195, the total thickness of the ledge is 130 feet, the strata being overturned and now dipping southward at an angle of 76 degress, with only about 50 feet of the deposit being utilized. The product is brown in color, irregular in size owing to the presence of numerous small quartz pebbles, and contains a considerable percentage of finely pulverized chert, but appears to be satisfactory for many purposes.

Eastward from this quarry for about one mile the Oriskany makes several low and discontinuous knobs where it has been much disintegrated and where it is being shoveled out for local building purposes, its character being much the same as at the quarry.

In the central and northwestern part of Monroe County, where the rocks are predominantly calcareous with a consequent deficiency of local sand beds, a valuable supply of sand may be obtained from the Droop Sandstone of the Bluefield Group of the Mauch Chunk Series, which forms a 50-foot ledge that often weathers out in great quantities of white sand. This is the case on the Swoopes Knobs plateau in the vicinity of Knobs village west of Union; on the ridge between Wayside and Sarton, on the western slope of Flattop Mountain, and on the ridge near Mt. Pleasant School southeast of Alderson. Even after the weathered supply is exhausted an unlimited quantity could be obtained at moderate cost by blasting and crushing, the material being quite free from pebbles and shale. The same ledge outcrops in Wind Creek Mountain southeast of Talcott, Summers County. Some further discussion of this ledge will be found under the subject of "Glass-Sand".

LIMESTONE.

The limestones of the three counties are by far their most valuable road building material. In Summers County the Avis Limestone of the Hinton Group of the Mauch Chunk

is available over a considerable part of the county; and along the Greenbrier River, near Talcott, Lowell, Riffe, Wolf Creek Station, and Alderson, the Raines Corner, Reynolds, and Glenray Limestones of the lower part of the Bluefield and the Alderson Limestone of the Greenbrier are above drainage at various points.

In Mercer County the Avis Limestone is available at many points along the Abbs Valley Anticline while farther south the limestones of the Bluefield, Greenbrier, Martinsburg, Moccasin, Stones River, and Beekmantown formations provide an unlimited supply.

In Monroe County the limestone beds of the Bluefield and Greenbrier are available at many points in the northwestern part, while in the central portion around Union the members of the Greenbrier make abundant outcrops of which much advantage has already been taken in surfacing State and county roads. Farther south the Martinsburg, Moccasin, Stones River, and Beekmantown Series afford inexhaustible material along the northern slope and foot-hills of Peters Mountain, and along the Back Valley Anticline in Potts Valley the Moccasin and Stones River are exposed.

BRICK MATERIAL.

As stated on previous pages, under the heading of "Stratified Shales", there is an abundance of material that can be made into brick, some of which might be durable enough for road surfacing provided a subgrade of concrete be provided to take up the shock of traffic. It is not probable, however, that the local materials would make as good paving blocks as the fire clays of northern West Virginia.

STONE FOR MASONRY, MACADAM, AND CONCRETE.

As stated on pages 789-791, under the subject of "Building Stone," there are many sandstone ledges in the three counties that can be used for general masonry construction, as well as for concrete aggregate if limestone or gravel is not locally available. Sandstone is not ideal for

macadam and with the great amount of available limestone there would appear to be little necessity for its use as such but if desired the Princeton and Stony Gap Sandstones of the Mauch Chunk, the Lackawaxen Conglomerate of the Chemung, the Keefer and Iron Sandstones of the Clinton, and the White Medina Sandstone of the Silurian would all provide exceptionally durable material.

The following table gives a list of the principal sandstones that would prove suitable for quarrying, together with references to the pages on which they have been described, those printed in full-faced type having already been used in masonry construction in the three counties:

Table of Sandstones Available for Masonry Construction.

Name of Sandstone.	Geological Series and Group.	Approximate Thickness. Feet.	Pages on which Described.
Pineville	Pottsville—New River	45 to 60	282-3
Flattop Mountain	Pottsville—Pocahontas	20 to 50	283-4
Pierpont	Pottsville—Pocahontas	30 to 40	284
Upper Pocahontas	Pottsville—Pocahontas	25 to 55	286
Keystone	Pottsville—Pocahontas	0 to 30	287-8
Upper Belcher	Mauch Chunk—Bluestone	15 to 25	318
Glady Fork	Mauch Chunk—Bluestone	25 to 40	321-2
Princeton	Mauch Chunk—Princeton	20 to 50	326-30
Falls Mills	Mauch Chunk—Hinton	25 to 50	335-6
Tallery	Mauch Chunk—Hinton	15 to 25	340-1
Hackett	Mauch Chunk—Hinton	30 to 45	353-4
Upper Bellepoint	Mauch Chunk—Hinton	30 to 40	360-2
Stony Gap	Mauch Chunk—Hinton	35 to 85	371-8
Clayton	Mauch Chunk—Bluefield	20 to 30	383-4
Graham	Mauch Chunk—Bluefield	15 to 30	385-6
Bertha	Mauch Chunk—Bluefield	30 to 50	391-2
Bradshaw	Mauch Chunk—Bluefield	30 to 50	394-7
Indian Mills	Mauch Chunk—Bluefield	30 to 60	400-1
Logan	Pocono	0 to 250	512-13
Broad Ford	Pocono	50 to 250	520-5
Berea	Pocono	25 to 150	529-31
Oriskany	Oriskany	50 to 150	566-72
Keefer	Clinton	25 to 100	587-8
Iron Sandstone	Clinton	25 to 75	590-1
White Medina	White Medina	50 to 150	592-5

In addition to the sandstones listed in the above table some others are locally massive and might afford occasional good stone.

The limestone of the three counties, of which there are many that are suitable for road macadam, have already been fully described in Chapters VII, VIII, XII, and XIV of this Report.

GLASS-SAND.

No development of glass-sand has been attempted in the three counties, although there are deposits which merit attention. Briefly enumerated, the requisites of a glass-sand are a high content of silica, low content of iron and other impurities that color the glass when burned in a furnace, freedom from quartz pebbles which require an excessively high temperature for melting, and a favorable quarry site where the material can be produced at low cost along some good line of transportation.

In Summers County the Pineville Sandstone of the New River Group of the Mauch Chunk Series forms the top of Hump Mountain east of Meadow Creek Station on the Chesapeake and Ohio Railway and south of Claypool on the Sewell Valley Railroad. This ledge is white, massive, and 55 feet thick, evidently high in silica and practically free from impurities, there being several acres without cover. A sample of the same ledge collected by Ray V. Hennen in Greenbrier County on Meadow River near the mouth of Burdette Creek, showed a silica content of 98.93 per cent., as published on page 912 of the Fayette County Report of the Survey. As already described in the present Report, pages 282-283, this sandstone occurs in only a few of the high mountains in northern Summers County but along the western edge and in the western part of Mercer County it should make a considerable outcrop, although no investigation of this further outcrop was made by the writer, the region being outside of the territory assigned for study. A detailed study of all the factors involved, includ-

ing many samples of the stone for analysis would of course be required before any particular locality could be pronounced entirely suitable for a glass-sand quarry, but the possibilities of the ledge are such that an investigation of this kind on the part of those interested would appear to be justified.

In the northwestern part of Monroe County the Droop Sandstone of the Bluefield Group of the Mauch Chunk Series, previously described on pages 415-418, is a white, massive ledge, 40 to 60 feet thick, entirely free from pebbles and having so little cementing material that it weathers into deep beds of white sand along the county roads. It covers the top of the Swoopes Knobs plateau west of Union, forms the western slope of Flattop Mountain southwest of Frazier, dips westward into the valley of Laurel Creek and again makes a ridge top near Mt. Pleasant School southeast of Alderson, while the Greenbrier River cuts a deep gorge through these escarpments and the outcrop is then continued northeastward into Greenbrier County along Muddy Creek Mountain. Farther west, as already described, it occurs in other ridges some of which are in Summers County.

Owing to the stress of many other matters which claimed attention the writer obtained no samples of this rock when in the field but at his request Mr. J. A. Kerr, of the United States Soil Survey, has very kindly collected four samples in the region south of Alderson, these being analyzed by Mr. Kaplan in the West Virginia Geological Survey laboratory as follows:

	1-A	2-A	B	C
Silica (SiO_2)	97.00	97.02	95.30	97.75
Ferric Iron (Fe_2O_3)	0.16	0.35	0.51	0.13
Alumina (Al_2O_3)	1.63	1.66	2.63	0.97
Manganous Oxide (MnO)	None	None	....	None
Lime (CaO)	None	None	0.10	0.04
Magnesia (MgO)	Trace	Trace	0.08	0.06
Potassium (K_2O) and Sodium (Na_2O)	0.41	0.41	0.52	0.42
Loss on ignition	0.60	0.60	0.70	0.50
Totals	99.80	100.04	99.84	99.87

Sample 1-A.—Upper 15 feet of a 60-foot ledge along road ascending mountain 0.9 mile southeast of Alderson. Land of Floyd Thomas.

Sample 2-A.—Lower 45 feet of a 60-foot ledge along road ascending mountain 0.9 mile southeast of Alderson. Land of Floyd Thomas.

Sample B.—Upper 20 feet of ledge near road ascending mountain one mile southeast of Alderson. Land of Floyd Thomas.
Sample C.—From 30-foot ledge along ridge road 0.8 mile south of Mt. Pleasant School and 2.2 miles southeast of Alderson. Land of Ernest Vance.

In taking the above samples Mr. Kerr reported that he was unable to dig deeply into the face of the cliff to get strictly unweathered samples on account of the lack of suitable equipment, and hence the material secured hardly does full justice to the ledge, some of the pieces being tinged red with iron and others being partly impregnated with organic slime. It is not apparent just what effect the slime may have had on the analyses but in the case of the iron it is quite possible that some of it may have come from the infiltration of surface water since the ledge generally shows few incrustations of this sort and the thoroughly weathered sand in the roads is nearly white. The samples were not washed before analysis and it is quite probable that such treatment, which is customary at nearly all sand plants, would remove a considerable amount of iron and alumina, and if that should be the case the utilization of the sand would appear to be quite possible.

In view of the very great amount of this sandstone in the tops of the ridges southeast of Alderson, where it is practically free from cover and where it could easily be quarried and lowered by gravity plane to the main line of the Chesapeake and Ohio Railway along Greenbrier River where there is ample water for washing it at all seasons of the year, the writer is of the opinion that a careful prospecting of the locality with the diamond drill to secure absolutely clean and unweathered samples might be undertaken with profit by those who may be interested in the glass-sand industry.

PART IV.

Paleobotany and Paleontology.

CHAPTER XVII.

PALEOBOTANY.

INTRODUCTION.

By **David B. Reger.**

As previously stated in this Report Dr. David White, Senior Geologist, United States Geological Survey, and one of the foremost authorities on paleobotany in the world, has most graciously undertaken the identification and discussion of the Mississippian floral collections of Mercer, Monroe, and Summers Counties, as well as certain others made by the writer in other counties and States in the course of special studies on correlation. The work of Dr. White was designed to include not only the identification of common or known forms but also the systematic description of new species and the illustration of new, or unusually good or otherwise important, specimens which have unusual interest.

In the local area there are plant fossils at many horizons, including not only the Mauch Chunk and Pocono Series where there are occasional coals or coaly shales and where such remains might confidently be expected, but also the intermediate Greenbrier Series composed almost entirely of marine limestones and having no coal. The presence of land plants in such environment has been a puzzling discovery and an adequate explanation of the phenomenon yet remains to be made. As already stated this series contains two or

three well-defined horizons of this sort, one of which has an apparent geographic range of about 200 miles through the central Appalachian region.

In the Mauch Chunk Series of the local area plant remains are quite common but in most cases the foliage has been badly macerated by the deposition of mud or sand which usually terminated their growth, leaving in less-disturbed condition only the stems and rootlets which give little clue to the specific identifications. With such material it is often necesary to search many hours at various localities in order to find diagnostic twigs or leaves even though the evidence of plant growth may be abundant.

In the Greenbrier and Maccrady Series conditions are much the same as in the Mauch Chunk except that the remains are much more limited, both in frequency of occurrence and in quantity of material. In the Pocono Series, however, where carboniferous growth was less interrupted by marine invasions or by the peculiar conditions attendant on the deposition of red shale, whatever these may have been, there are well-preserved plant specimens affording the necessary details for identification in most cases.

In the local area or closely contiguous territory 15 plant collections were made in the Mauch Chunk, five in the Greenbrier, and two in Pocono, the latter series being less interesting because its floras are already better known. A few of these 22 collections were made by the writer in the course of stratigraphic studies but most of them were taken by Dr. David White himself during a week's trip to the territory accompanied by Paul H. Price and the writer. Other collections have also been made by Dr. White in this same region in former years but no list of them is on file with the West Virginia Survey.

In Chapters V, VII, VIII, and IX, dealing with stratigraphy, all these recent Mississippian plant collections were mentioned and the lists and discussions by Dr. White in the present Chapter were called for, but after these four Chapters had been printed Dr. White, most regrettably, found that his numerous other engagements would not permit the completion of this study in time for publication. Consequently,

instead of the full lists, descriptions, and illustrations, it is now possible to publish only a preliminary statement on "General Features of the Mississippian Floras of the Appalachian Trough" by Dr. White. This paper appears on later pages of this Chapter and affords a valuable addition to our knowledge of the Mississippian.

In a future volume, devoted exclusively to the Mississippian of the Appalachian States and undertaken with the purpose of definitely correlating the rocks of this age in West Virginia with those of the same period in other States, it is expected that all these collections in the three counties herein studied, together with those made by the writer in other States and those made by Dr. White himself in the Mississippian rocks of the Appalachian territory, will be fully presented, with adequate illustrations and discussions by Dr. White.

List of Fossil Localities.—In the following table there is published a List of Fossil Localities, including not only the plant collections now in possession of and under study by Dr. David White, but also the Pennsylvanian and Mississippian invertebrate collections in the hands of Dr. George H. Girty, and the Devonian, Silurian, and Ordovician localities which were studied by Dr. Wm. F. Prouty, the work of these latter two paleontologists being mentioned in more detail in Chapter XVIII. This combined list includes all collections in the three counties or bordering localities but does not include certain others made in more distant territory and not pertinent to this Report.

On Maps II, IV, and VI, the exact localities and lot numbers of the West Virginia Geological Survey, corresponding to those in the list as printed or as otherwise used in this Report, are engraved in red, making easy the field identification of these points in case other investigators desire to study them in more detail. The lot or catalog numbers of the United States Geological Survey, as assigned by Dr. Girty to his collections, are also published in the list.

Elsewhere in this Report no mention has been made of **Lot 257,** collected from residual clay overlying the upturned edges of limestones of the Greenbrier Series in an extensive

excavation along the Norfolk and Western Railway 1.3 miles southwest of Bluefield (West Virginia) Station which was under progress in the summer of 1924. At this locality there is a cavern in the limestone while in its immediate vicinity the residual clay is ten feet or more thick and contains fragments of bones some of which protruded from the excavation and others of which were mixed in the fill but were reported as having partly come from beneath the clay. It was also known that a slaughter-house had occupied the site in comparatively recent years.

Some large teeth, evidently old and reported as having come from the clay, were handed to Mr. H. R. Hunter, a resident, who reported the find to the local press, arousing much interest, especially in view of the remains of Mastodon which were long ago found in residual clays covering the Maccrady Series of the Mississippian near Saltville, Virginia, 40 or 50 miles southwest of Bluefield.

A collection (Lot 257) was made by the writer, with the help of Mr. W. R. Crenshaw of Bluefield, from the older bones and teeth projecting from the clay or scattered about the new fill, and was forwarded to paleontologists of the United States National Museum who reported that all the material was recent and therefore of no paleontologic interest.

Although not sanguine from the first about the possible antiquity of these bones, some of which were known to be mixed with lately dumped material, the writer considered the collection worth while in order to be certain that no possibility of ancient vertebrates had been overlooked and in order to make authoritative report to the interested citizens of Bluefield. After all, the results have bearing on only one locality and collection. Considering the finds at Saltville there is a good possibility that vertebrate fossils of Pleistocene age may yet be found in the residual clays and limestone caves of the local area and there is also the much more interesting possibility that some of the caves may have served as refuges for human beings when the northern half of the present United States was covered with ice.

The List of Fossil Localities and the paper of Dr. David White follow herewith in the order named:

List of Fossil Localities, Mercer, Monroe and Summers Counties.

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
1	....	Maccrady	.....	Marine	Beaver Pond Dist., Mercer Co.; in Bluefield along Federal St. just south of Scott St.....	.....	No. 2 of Bluefield Section	Prouty and Reger.	W. F. Prouty.
2	....	Pocono	Broad Ford Sandstone ...	Marine	Beaver Pond Dist., Mercer Co.; in excavation for Bailey Building, 100′ S. W. of Bluefield P. O.....	.....	No. 11 of Bluefield Section	Prouty and Reger.	W. F. Prouty.
3	....	Marcullus	In Black Shale..	Marine	Bland Co., Va.; on branch of Laurel Creek at foot of East River Mountain, 2 miles N. W. of Rocky Gap.....	2360′ B	None	Prouty and Reger.	W. F. Prouty.
4	....	White Medina	50 to 75′ above base...	Marine?	Bland Co., Va.; in road on summit of East River Mountain, 2.5 miles S. E. of Bluefield.....	3450′ B	None	Prouty and Reger.	W. F. Prouty.
5	....	Red Medina	Near middle....	Marine?	Beaver Pond Dist., Mercer Co.; in road on north side of East River Mt.; 2.1 S. E. of Bluefield Station.....	3360′ B	None	Prouty and Reger.	W. F. Prouty.
6	....	Martinsburg	Near top.....	Marine	Beaver Pond Dist., Mercer Co.; in road on north side of East River Mt., 2 miles S. E. of Bluefield Station.....	3260′ B	None	Prouty and Reger.	W. F. Prouty.
7	....	Martinsburg	Lower than Lot 6.....	Marine	Beaver Pond Dist., Mercer Co.; in road on north side of East River Mt.; 2 miles S. E. of Bluefield Station.....	3065′ B	None	Prouty and Reger.	W. F. Prouty.
8	....	Martinsburg	Lower than Lot 7.....	Marine	Beaver Pond Dist., Mercer Co.; in road on north side of East River Mt., 2 miles S. E. of Bluefield Station.....	3045′ B	None	Prouty and Reger.	W. F. Prouty.
9	....	Martinsburg	Lower than Lot 8.....	Marine	Beaver Pond Dist.,, Mercer Co.; in road on north side of East River Mt., 2 miles S. E. of Bluefield Station.....	3035′ B	None	Prouty and Reger.	W. F. Prouty.
10	....	Martinsburg	Lower than Lot 9.....	Marine	Beaver Pond Dist., Mercer Co.; in road on north side of East River Mt., 2 miles S. E. of Bluefield Station.....	2940′ B	None	Prouty and Reger.	W. F. Prouty.
11	....	Martinsburg	Lower than Lot 10 and near base	Marine	Beaver Pond Dist., Mercer Co.; in road on north side of East River Mt., 2 miles S. E. of Bluefield Station.....	2905′ B	None	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
12	....	Stones River (Chiekamauga) Limestone	Upper part?....	Marine	Beaver Pond Dist., Mercer Co.; at R. F. Baker quarry on south side of Beaver Pond Creek 1.7 miles S. W. of Bluefield Station.....	2455′ B	None	Prouty and Reger.	W. F. Prouty.
13	....	Poeono and Chemung	Contaet zone...	Marine	Tazewell Co., Va.; in street on east side of Beaver Pond Creek at southern edge of Bluefield, Va. (Graham).....	2415′ B	Local Measurement	Prouty and Reger.	W. F. Prouty.
14	....	Mauch Chunk—Bluefield Group..	Glenray Limestone	Marine	Tazewell Co., Va.; in N. & W. cut on Bluestone River 0.1 mile N. W. of Bluefield, Va. (Graham) Station and just N. W. of junction with Clineh Valley Division.....	.....	No. 21 of Graham Section	Prouty and Reger	G.H. Girty.
15	5663	Pocono	Broad Ford Sandstone ...	Marine	Giles Co., Va.; in N. & W. Ry. eut 1.2 miles S. E. of Lurich.....	1550′ B	No. 23 of Lurieh Seetion	Prouty and Reger.	W. F. Prouty.
16	....	Chemung	Less than 100′ above base...	Marine	Giles Co., Va.; in N. & W. cut 1.3 miles S. E. of Lurieh.....	1550′ B	No. 28 of Lurich Seetion	Prouty and Reger.	W. F. Prouty.
17	....	Chemung	Lower than Lot 16.....	Marine	Giles Co., Va.; in N. & W. Ry. cut 1.3 miles S. E. of Lurieh.....	1550′ B	No. 28 of Lurieh Section	Prouty and Reger.	W. F. Prouty.
18	....	Chemung	Lower than Lot 17 and near base	Marine	Giles Co., Va.; in N. & W. Ry. cut 1.3 miles S. E. of Lurieh.....	1550′ B	No. 28 of Lurieh Seetion	Prouty and Reger.	W. F. Prouty.
19	....	Stones River (Chiekamauga)	Basal portion..	Marine	Giles Co., Va.; in N. & W. Ry. cut 2.1 miles north of Narrows.....	1555′ B	No. 36 of Lurich Seetion	Prouty and Reger.	W. F. Prouty.
20	....	Stones River (Chiekamauga)	Middle portion..	Marine	Giles Co., Va.; in N. & W. Ry. eut, 2 miles north of Narrows.....	1555′ B	No. 37 of Lurich Section	Prouty and Reger.	W. F. Prouty.
21	....	Stones River (Chickamauga)	Upper portion..	Marine	Giles Co., Va.; in N. & W. Ry. cut 1.9 miles north of Narrows.....	1555′ B	No. 37 of Lurich Seetion	Prouty and Reger.	W. F. Prouty.
22	....	Martinsburg-Lower Maysville Group..	Lingula Zone..	Marine	Giles Co., Va.; in road on east side of New River 1.3 miles north of Narrows.	1600′ B	No. 12 of Rich Creek Seetion	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
23	....	Martinsburg-Lower Maysville Group..	Orthorhynchula Zone	Marine	Giles Co., Va.; in road on east side of New River 1.3 miles north of Narrows..	1590′ B	No. 13 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
24	....	Martinsburg-Lower Maysville Group..	Orthorhynchula Zone	Marine	Giles Co., Va.; in road on east side of New River 1.4 miles north of Narrows..	1620′ B	No. 14 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
25	....	Martinsburg-Eden Group	At top	Marine	Giles Co., Va.; in road on east side of New River 1.4 miles north of Narrows..	1600′ B	No. 16 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
26	....	Martinsburg-Eden Group	Limestone and shale below Lot 25	Marine	Giles Co., Va.; in road on east side of New River 1.5 miles north of Narrows..	1570′ B	No. 18 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
27	....	Martinsburg-Eden Group	Limestone and shale below Lot 26	Marine	Giles Co., Va.; in road on east side of New River 1.6 miles north of Narrows..	1570′ B	No. 19 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
28	....	Martinsburg-Eden Group	Limestone and shale below Lot 27	Marine	Giles Co., Va.; in road on east side of New River 1.7 miles north of Narrows..	1560′ B	No. 20 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
29	....	Martinsburg-Eden Group	Limestone and shale at base..	Marine	Giles Co., Va.; in road on east side of New River 1.7 miles north of Narrows..	1560′ B	No. 22 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
30	....	Martinsburg-Trenton Group	At top	Marine	Giles Co., Va.; in road on east side of New River 1.7 miles north of Narrows..	1550′ B	No. 23 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
31	....	Martinsburg-Trenton Group	Middle portion..	Marine	Giles Co., Va.; in road on east side of New River 1.8 miles north of Narrows..	1570′ B	No. 26 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
32	....	Martinsburg-Trenton Group	Below middle..	Marine	Giles Co., Va.; in road on east side of New River 1.8 miles north of Narrows..	1595′ B	No. 27 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
33	....	Clinton	Shale about 50′ above Iron Sandstone ...	Marine	Giles Co., Va.; in road on east side of New River 1.2 miles north of Narrows. (Collection lost).....	1580′ B	No. 6 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
34	....	Clinton	Shale above Lot 33.....	Marine	Giles Co., Va.; in road on east side of New River 1.1 miles north of Narrows..	1580′ B	No. 6 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
35	....	Clinton	Shale above Lot 34	Marine	Giles Co., Va.; in road on east side of New River 1.1 miles north of Narrows..	1580′ B	No. 6 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
36	....	Clinton	Shale above Lot 35	Marine	Giles Co., Va.; in road on east side of New River 1 mile north of Narrows....	1580′ B	No. 6 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
37	....	Clinton	Fossil Ore Horizon	Marine	Giles Co., Va.; in road on east side of New River 1 mile north of Narrows....	1590′ B	No. 5 of Rich Creek Section	Prouty and Reger.	W. F. Prouty.
38	....	Oriskany? or Helderburg?	Ridgeley Sandstone or New Scotland Chert	Marine	Tazewell Co., Va.; in excavation on eastern side of Beaver Pond Creek near main entrance to Bluefield Fair-Grounds (Collection mixed—no list reported)..	2435′ B	No. 2 of Bluefield Fair Grounds Section	Prouty.	W. F. Prouty.
39	....	Oriskany? or Helderburg?	Ridgeley Sandstone or New Scotland Chert	Marine	Tazewell Co., Va.; northern side of Beaver Pond Creek at west end of race track in Bluefield Fair-Grounds (collection in fault—no list reported)....	.....	None	Prouty.	W. F. Prouty.
40	....	Chemung	400 to 500′ below top...	Marine	Beaver Pond Dist., Mercer Co.; in N. & W. Ry. cut, I mile W. of Blake.....	2060′ B	No. 13 of Blake Section	Prouty and Reger.	W. F. Prouty.
41	....	Chemung	250 to 400′ below top....	Marine	Beaver Pond Dist., Mercer Co., in N. & W. Ry. cut, 1.2 miles W. of Blake.....	2070′ B	No. 13 of Blake Section	Prouty and Reger.	W. F. Prouty.
42	....	Chemung	182′ below top.	Marine	Beaver Pond Dist., Mercer Co., in N. & W. Ry. cut, 1.3 miles W. of Blake.....	2085′ B	No. 11 of Blake Section	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
43	....	Chemung	Near top	Marine	Beaver Pond Dist., Mercer Co., in N. & W. Ry. cut, 1.4 miles W. of Blake.....	2085' B	No. 9 of Blake Section	Prouty and Reger.	W. F. Prouty.
43A	....	Mauch Chunk-Bluefield Group..	Raines Corner Limestone, Ada Shale, etc.....	Marine	Beaver Pond Dist., Mercer Co.; in road north of East River and 0.3 to 0.5 mile W. of Ada. (No report, probably lost)	.....	Local Measurement	Prouty and Reger.	E. M. Kindle
44	....	Stones River (Chickamauga) Limestone	Upper portion..	Marine	East River Dist., Mercer Co.; on head of Pigeon Creek just west of residence of Floyd Dickson, 2.1 miles south of Oakvale	2280' B	None	Prouty.	W. F. Prouty.
45	....	Stones River (Chickamauga) Limestone or Chambersburg? ..	Contact Zone..	Marine	East River Dist., Mercer Co.; on head of Pigeon Creek 0.3 mile north of residence of Floyd Dickson and 1.8 miles south of Oakvale.....	.....	None	Prouty.	W. F. Prouty.
46	....	Stones River (Chickamauga) Limestone or Chambersburg? ..	.....	Marine	East River Dist., Mercer Co.; on head of Pigeon Creek 0.5 mile north of residence of Floyd Dickson and 1.6 miles south of Oakvale.....	2155' B	None	Prouty and Reger.	W. F. Prouty.
47	....	Stones River (Chickamauga) Limestone	Upper portion of Middle Stones River..	Marine	Beaver Pond Dist., Mercer Co.; at foot of East River Mountain 0.6 mile N. E. of Bailey School and 1.6 miles S. E. of Bluefield Station; quarry of S. J. Sublette	2715' B	Local Measurement	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
48	....	Stones River (Chickamauga) Limestone	Lower portion of Upper Stones River..	Marine	Beaver Pond Dist., Mercer Co.; at foot of East River Mountain, 0.6 mile N. E. of Bailey School and 1.6 miles S. E. of Bluefield Station; quarry of S. J. Sublette	2745′ B	Local Measurement	Prouty and Reger.	W. F. Prouty.
49	....	Beekmantown Limestone	Middle portion..	Lithologic Specimen	Beaver Pond Dist., Mercer Co.; on knoll at head of Grassy Branch of East River 0.3 mile S. E. of residence of Robert Tuggle and 1.3 miles S. E. of Bluefield Station	.....	None	Prouty and Reger.	W. F. Prouty.
50	....	Beekmantown Limestone	Lower portion..	Lithologic Specimen	Beaver Pond Dist., Mercer Co., at residence of Robert Tuggle on head of Grassy Branch of East River 1.1 miles S. E. of Bluefield Station.....	2650′ B	None	Prouty.	W. F. Prouty.
51	....	Beekmantown Limestone	.....	Lithologic Specimen	Beaver Pond Dist., Mercer Co.; in road on southern branch of East River 1 mile south of Ada and 0.2 mile north of Thompson School.....	.....	.....	Prouty.	W. F. Prouty.
52	....	Beekmantown? Limestone or Elbrook?	.....	Lithologic Specimen	Beaver Pond Dist., Mercer Co.; on ridge south of Beaver Pond Creek and 0.7 S. E. of Bluefield Station.....	.....	.....	Prouty.	W. F. Prouty.
53	....	Stones River (Chickamauga) Limestone or Chambersburg? ..	Contact zone ..	Marine	Red Sulphur Dist., Monroe Co.; lower northern slope of Peters Mountain 1.2 miles S. W. of Green Valley School and 3.1 miles S. E. of Peterstown.....	2340′ B	None	Prouty and Reger.	W. F. Prouty.
54	....	Stones River (Chickamauga) Limestone	Middle portion..	Lithologic Specimen	Red Sulphur Dist., Monroe Co.; in sink on lower northern slope of Peters Mountain 1.1 miles S. W. of Green Valley School and 3.1 miles S. E. of Peterstown	.....	None	Prouty and Reger	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
55	....	Stones River (Chickamauga) Limestone	Lower portion..	Marine	Red Sulphur Dist., Monroe Co.; on knoll just north of sink on lower northern slope of Peters Mt., 1.1 miles S. W. of Green Valley School and 3.1 miles S. E. of Peterstown.....	2310′ B	None	Prouty and Reger	W. F. Prouty.
56	....	Beekmantown Limestone	Lower portion..	Lithologic Specimen	Sweet Springs Dist., Monroe Co.; in road on north side of Kitchen Creek 0.8 mile N. E. of Gap Mills.....	2385′ B	None	Prouty and Reger	W. F. Prouty.
57	....	Marcellus	Lower Selinsgrove Limestone	Marine	Sweet Springs Dist., Monroe Co.; in road on branch of Cove Creek 1.4 miles N. W. of Sweet Springs. (Collection lost)	.....	Local Measurement	Prouty and Reger	W. F. Prouty.
58	....	Stones River (Chickamauga) Limestone	In upper half.	Marine	Sweet Springs Dist., Monroe Co.; on branch of Sweet Springs Creek 0.3 mile W. of Sweet Springs.....	2025′ B	None	Prouty and Reger	W. F. Prouty.
59	....	Clinton	.....	Marine	Sweet Springs Dist., Monroe Co.; in gap of Ewin Run, through Little Mountain 0.1 mile north of Sugar Grove School and 1.5 miles south of Linton.....	.....	None	Prouty.	W. F. Prouty.
60	....	Stones River (Chickamauga)? or Chambersburg? Limestone	.....	Marine	Giles Co., Va.; at Kimballton Lime Co. quarry at Kimballton on south side of Stony Creek.....	.....	None	Prouty.	W. F. Prouty.
61	....	Martinsburg	.....	Marine	Sweet Springs Dist., Monroe Co.; in road on Ewin Run of Potts Creek 0.1 mile N. E. of Sugar Grove School and 1.6 miles south of Linton.....	2270′ B	None	Prouty and Reger	W. F. Prouty.
62	....	Stones River (Chickamauga)? or Chambersburg? Limestone	.....	Marine	Sweet Springs Dist., Monroe Co.; on Ewin Run of Potts Creek at Sugar Grove School, 1.7 miles south of Linton.....	2300′ B	None	Prouty and Reger	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
63	....	Martinsburg Shale-Lower Maysville Group	Lingula Zone...	Marine	Sweet Springs Dist., Monroe Co.; on Trout Branch of Potts Creek, 1.9 miles S. E. of Laurel Branch.....	2410′ B	None	Prouty and Reger	W. F. Prouty.
64	....	Genesee	.....	Marine	Sweet Springs Dist., Monroe Co.; in road north of Potts Creek and 2.5 miles S. W. of Laurel Branch.....	2105′ B	None	Prouty and Reger	W. F. Prouty.
65	....	Genesee	.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mountain 0.2 mile N. of Laurel Branch, Potts Valley.....	2145′ B	None	Prouty and Reger	W. F. Prouty.
66	....	Hamilton	Lower portion..	Marine	Sweet Springs Dist., in road ascending Peters Mountain, 0.4 mile N. E. of Laurel Branch, Potts Valley.....	2270′ B	Local Measurement	Prouty and Reger	W. F. Prouty.
67	....	Clinton	Fossil Ore Horizon	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mountain, 0.7 mile northward from Laurel Branch, Potts Valley	3020′ B	Local Measurement	Prouty and Reger	W. F. Prouty.
68	....	Beekmantown Limestone	Lower portion..	Lithologic Specimen	Sweet Springs Dist., Monroe Co.; in road 0.6 mile S. W. of Gap Mills.....	2420′ B	None.	Prouty and Reger	W. F. Prouty.
69	....	Beekmantown .... Limestone	Upper portion..	Marine	Sweet Springs Dist., Monroe Co.; in low ridge north of Peters Mountain 1.3 miles N. E. of Crimson Springs Church and 3.1 miles S. W. of Gap Mills.....	2670′ B	No. 36 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
70	....	Stones River (Chickamauga) Limestone	Across outcrop..	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mountain 3.3 miles S. W. of Gap Mills.....	.....	No. 35 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
71	....	Martinsburg-Lower Maysville Group..	Lingula and Orthorhynchula Zones.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 0.7 mile E. of Hanging Rock and 4.3 miles S. W. of Gap Mills.....	3325′ B	No. 3 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
72	....	Martinsburg-Trenton Group	Yellow shale, bottom zone..	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.5 miles S. W. of Gap Mills.....	.....	No. 32 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
73	....	Martinsburg-Trenton Group	Yellow shale, just above Lot 72.....	Marine	Sweet Springs Dist., Monroe Co.; in road aseending Peters Mt., 3.5 miles S. W. of Gap Mills.....	.....	No. 31 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
74	....	Martinsburg-Trenton Group	Yellow shale, just above Lot 73.....	Marine	Sweet Springs Dist., Monroe Co.; in road aseending Peters Mt., 3.5 miles S. W. of Gap Mills.....	.....	No. 30 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
75	....	Martinsburg-Trenton Group	Yellow shale, just above Lot 74.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.5 miles S. W. of Gap Mills.....	.....	No. 29 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
76	....	Martinsburg-Trenton Group	Yellow shale, just above Lot 75.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.5 miles S. W. of Gap Mills.....	.....	No. 28 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
77	....	Martinsburg-Trenton Group	Yellow shale, just above Lot 76.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.5 miles S. W. of Gap Mills.....	.....	No. 27 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
78	....	Martinsburg-Trenton Group	Blue limestone just above Lot 77.....	Marine	Sweet Springs Dist., Monroe Co.; in road aseending Peters Mt., 3.5 miles S. W. of Gap Mills.....	.....	No. 26 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
79	....	Martinsburg-Trenton Group	Blue limestone just above Lot 78.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 25 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
80	....	Martinsburg-Trenton Group	Blue limestone just above Lot 79.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 24 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
81	....	Martinsburg-Trenton Group	Blue limestone just above Lot 80.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 23 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
82	....	Martinsburg-Trenton Group	Blue limestone just above Lot 81.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 22 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
83	....	Martinsburg-Trenton Group	Blue limestone just above Lot 82.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 21 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
84	....	Martinsburg-Trenton Group	Yellow shale just above Lot 83.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 20 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
85	....	Martinsburg-Trenton Group	Limestone and shale just above Lot 84.	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 19 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
86	....	Martinsburg-Trenton Group	Limestone and shale just above Lot 85.	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 18 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
87	....	Martinsburg-Trenton Group	Limestone and shale just above Lot 86.	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 17 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
88	....	Martinsburg-Trenton Group.....	Limestone just above Lot 87.	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 16 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
89	....	Martinsburg-Trenton Group	Limestone and shale just above Lot 88.	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 15 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
90	....	Martinsburg-Trenton Group	Yellow shale and limestone just above Lot 89.	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W of Gap Mills.....	.....	No. 14 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
91	....	Martinsburg-Trenton Group	Shaly limestone just above Lot 90.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W of Gap Mills.....	.....	No. 13 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.
92	....	Martinsburg-Trenton Group	Shaly limestone just above Lot 91.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 12 of Hanging Rock Section.	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
93	....	Martinsburg-Trenton Group	Shaly limestone just above Lot 92.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 11 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
94	....	Martinsburg-Trenton Group	Shaly limestone just above Lot 93.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 10 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
95	....	Martinsburg-Trenton Group	Shaly limestone just above Lot 94.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 9 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
96	....	Martinsburg-Trenton Group	Shaly limestone just above Lot 95.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 8 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
97	....	Martinsburg-Trenton Group	Shale and limestone, near top.....	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	.....	No. 7 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
98	....	Martinsburg-Eden Group	Near base	Marine	Sweet Springs Dist., Monroe Co.; in road ascending Peters Mt., 3.6 miles S. W. of Gap Mills.....	2980′ B	No. 6 of Hanging Rock Section.	Prouty and Reger	W. F. Prouty.
99	....	Beekmantown Limestone	Near top.....	Lithologic Specimen	Sweet Springs Dist., Monroe Co.! in road at northern base of Peters Mt., 2.2 miles E. of Zenith.....	2560′ B	None.	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
101	....	Beekmantown Limestone	Upper part of Narrows Chert; type locality.	Marine	Giles Co., Va.; on a low spur of Wolf Creek Mt., west of Mill Creek and south of Wolf Creek, 2.2 miles S. W. of Narrows	2095′ B	No. 4 of Narrows Section.	Prouty and Reger.	W. F. Prouty.
102	....	Beekmantown Limestone	Middle part of Narrows Chert; type locality..	Marine	Giles Co., Va.; on a low spur of Wolf Creek Mt., west of Mill Creek and south of Wolf Creek, 2.2 miles S. W. of Narrows	2090′ B	No. 5 of Narrows Section.	Prouty and Reger.	W. F. Prouty.
103	....	Beekmantown Limestone	Lower part of Narrows Chert; type locality..	Marine	Giles Co., Va.; on a low spur of Wolf Creek Mt., west of Mill Creek and south of Wolf Creek, 2.2 miles S. W. of Narrows	2090′ B	No. 6 of Narrows Section.	Prouty and Reger.	W. F. Prouty.
104	....	Beekmantown Limestone	Chert coming 816-906′ below top.....	Marine	Giles Co., Va.; on a low spur of Wolf Creek Mt., west of Mill Creek and south of Wolf Creek, 2 miles S. W. of Narrows	1980′ B	No. 12 of Narrows Section.	Prouty and Reger.	W. F. Prouty.
105	....	Beekmantown Limestone	Chert coming 1294-1456′ below top....	Marine	Giles Co., Va.; on a low spur of Wolf Creek Mt., west of Mill Creek and south of Wolf Creek, 2 miles S. W. of Narrows. (May be loose drift—see discussion)	1855′ B	No. 14 of Narrows Section.	Prouty and Reger.	W. F. Prouty.
106	....	Beekmantown Limestone	Basal portion?..	Marine	Beaver Pond Dist., Mercer Co.; in Robert Tuggle hog lot on Grassy Branch of East River, 1.1 miles S. E. of Bluefield Station.....	2605′ B	None.	Prouty and Reger.	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
107	....	Beekmantown Limestone	Lower portion? above Lot 106	Marine	Beaver Pond Dist., Mercer Co.; 400 feet east of Rubert Tuggle barn on Grassy Branch of East River, 1.2 miles S. E. of Bluefield Station.....	2625′ B	None.	Prouty and Reger.	W. F. Prouty.
108	5610	Greenbrier	Sinks Grove Limestone ...	Marine	East River Dist., Mercer Co.; on Pigeon Creek, 0.3 mile above mouth and 0.8 mile S. E. of Oakvale.....	1740′ B	None.	Reger.	G. H. Gitry
109	5610	Beekmantown Limestone	Middle? or lower portion?	Marine	East River Dist., Mercer Co.; in road south of East River and 0.3 mile S. E. of Wills Station and just south of St. Clair Fault.....	1850′ B	None.	Reger.	W. F. Prouty
110	....	Pocono	In loose sandstone flag....	Plant	Beaver Pond Dist., Mercer Co.; on branch of East River 0.7 mile S. E. of Stony Gap and 1 mile S. W. of Ada.....	2360′ B	No. 95 of Stony Gap Section.	Reger.	David White.
111	5500	Greenbrier	Sinks Grove and Hillsdale Limestone ...	Marine	Beaver Pond Dist., Mercer Co.; on branch of East River 0.5 mile S. E. of Stony Gap and 1 mile S. W. of Ada.....	2335′ B	No. 92 of Stony Gap Section.	Reger.	G H. Girty.
112	5501	Greenbrier	Sinks Grove Limestone ...	Marine	Beaver Pond Dist., Mercer Co.; on branch of East River 0.5 mile S. E. of Stony Gap and 1 mile S. W. of Ada.....	2315′ B	No. 91 of Stony Gap Section.	Reger.	G. H. Girty.
113	5502	Greenbrier	Patton Limestone	Marine	Beaver Pond Dist., Mercer Co.; on branch of East River 0.5 mile S. E. of Stony Gap and 1 mile S. W. of Ada.....	2310′ B	No. 90 of Stony Gap Section.	Reger.	G. H. Girty.
114	5503	Greenbrier	Lower portion of Pickaway Limestone ...	Marine	Beaver Pond Dist., Mercer Co.; on branch of East River, 0.4 mile S. E. of Stony Gap and 1 mile S. W. of Ada.....	2300′ B	No. 88 of Stony Gap Section.	Reger.	G. H. Girty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Palcontologist.
115	5504	Greenbrier	Upper portion of Pickaway Limestone ...	Marine	Beaver Pond Dist., Mercer Co.; partly on East River at Ward Bailey quarry and partly on branch southward, 0.4 mi. S. E. of Stony Gap and 1 mi. S. W. of Ada	2295′ B	No. 87 of Stony Gap Section.	Reger.	G. H. Girty.
116	5505	Greenbrier	Union Limestone	Marine	Beaver Pond Dist., Mercer Co.; on north side of East River 0.4 mi. south of Stony Gap and just east of Bluefield water station; N. & W. Ry. cuts through lower part.....	2230′ B	No. 86 of Stony Gap Section.	Reger.	G. H. Girty.
117	5506	Greeenbier	Lower portion of Alderson Limestone ...	Marine	Beaver Pond Dist., Mercer Co.; on north side of East River 0.4 mi. south of Stony Gap.....	2225′ B	No. 85 of Stony Gap Section.	Reger.	G. H. Girty
118	5507	Greenbrier	Middle portion of Alderson Limestone ...	Marine and Plant	Beaver Pond Dist., Mercer Co.; on north side of East River 0.3 mile south of Stony Gap.....	2240′ B	No. 84 of Stony Gap Section.	Reger.	G. H. Girty.
119	5508	Greenbrier	Upper third of Alderson Limestone ...	Marine and Plant	Beaver Pond Dist., Mercer Co.; on Bluefield-Princeton highway 0.4 mi. S. W. of Stony Gap.....	2440′ B	No. 83 of Stony Gap Section.	Reger.	G. H. Girty.
120	5509	Mauch Chunk-Bluefield Group..	Ada Shale and Reynolds Limestone ...	Marine	Beaver Pond Dist., Mercer Co.; on Bluefield-Princeton highway, 0.4 mi. S. W. of Stony Gap.....	2470′ B	No. 81 of Stony Gap Section.	Reger.	G. H. Girty.
121	5510	Mauch Chunk-Bluefield Group..	Lower half of Lillydale Shale	Marine	Beaver Pond Dist., Mercer Co.; in N. & W. Ry. cut just west of Nemours Station	2305′ B	No. 11 of Nemours Station Section.	Reger and Girty	G. H. Girty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
122	5511	Mauch Chunk-Bluefield Group..	Coney Shale ...	Marine	Tazewell Co.; Va.; in highway north of Beaver Pond Creek, just east of its mouth and just north of Graham (Bluefield, Va.) Station.....	.....	None.	Reger.	G. H. Girty.
123	5512	Mauch Chunk-Bluefield Group..	**Graham Limestone** and **Upper Graham Shale**, mixed; **type locality** of both.....	Marine	Tazewell Co., Va.; in N. & W. Ry. cut, south side of Bluestone River 0.5 mi. N. W of Graham (Bluefield, Va.) Station	2365′ B	Nos. 3, 4, and 5 of Graham Section.	Reger and Girty	G. H. Girty.
124	....	Mauch Chunk-Bluefield Group..	Upper Graham Shale and Bertha Sandstone.	Plant	Tazewell Co., Va.; in N. & W. Ry. cut, south side of Bluestone River, 0.5 mile N. W. of Graham (Bluefield, Va.) Station	2365′ B	No. 6 and 9 of Graham Section.	Reger, D. White, and Price	David White.
125	5513	Mauch Chunk-Hinton Group....	Avis Limestone?	Marine	Tazewell Co., Va.; in N. & W. Ry. cut, east side of Bluestone River 0.6 mile N. W. of Graham (Bluefield, Va.) Station.	2360′ B	Local Measurement	Reger	G. H. Girty.
126	5514	Mauch Chunk-Hinton Group....	Terry Limestone	Marine	Tazewell Co., Va.; at west end of highway and railway bridges across Bluestone River, 1.1 mi. N. W. of Graham (Bluefield, Va.) Station.....	2355′ B	Local Measurement	Reger	G. H. Girty.
127	5515	Greenbrier	Union Limestone	Marine	Beaver Pond Dist., Mercer Co.; at McDowell County Stone quarry leased by B. K. Newell on north side of Bluestone River, 0.1 mile N. W. of Nemours P. O.	2295′ B	Local Measurement	Reger	G. H. Girty.
128	....	Greenbrier	Middle portion of Alderson Limestone ...	Plant	Beaver Pond Dist., Mercer Co.; on Bluefield-Princeton highway 0.4 mi. S. W. of Stony Gap.....	2440′ B	No. 83 of Stony Gap Section.	Reger	David White.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
129	....	Beekmantown Limestone	2400′ below top	Marine	Sweet Springs Dist., Monroe Co.; in chert pile along hill road ascending from Turkey Creek up a spur of Gap Mountain 1.9 mi. N. E. of McGlone.....	2570′ B	No. 37 of Hanging Rock Section.	Reger	W. F. Prouty.
130	5516	Greenbrier	Sinks Grove Limestone ...	Marine	Union Dist., Monroe Co.; on ridge road 0.3 mi. S. W. of Schley School and 1 mi. N. W. of Gates.....	2260′ B	None.	Reger	G. H. Girty
131	....	Chemung	340 to 540′ below top....	Marine	Sweet Springs Dist., Monroe Co.; in road 0.3 mi. south of Red Mill and just south of bridge across Second Creek....	2305′ B	No. 9 of Gap Mills Section.	Reger	W. F. Prouty.
132	....	.Beekmantown Limestone	Probably 1000′ below top ...	Marine	Sweet Springs Dist., Monroe Co.; in Gap Mills-Waiteville road 2.1 miles S. W. of Gap Mills.....	2475′ B	None.	Reger	W. F. Prouty.
133	....	Beekmantown Limestone	Probably 700′ below top ...	Marine	Sweet Springs Dist., Monroe Co.; in Gap Mills-Waiteville road, 2.4 miles S. W. of Gap Mills.....	2515′ B	None.	Reger	W. F. Prouty.
134	....	Beekmantown Limestone	Probably 900′ below top ...	Marine	Sweet Springs Dist., Monroe Co.; in Gap Mills-Waiteville road 2.2 miles S. W. of Gap Mills.....	2490′ B	None.	Reger	W. F. Prouty.
135	....	Marcellus	Lower Selinsgrove Limestone	Marine	Sweet Springs Dist., Monroe Co.; in N. & W. Ry. cut on north side of Potts Creek 1.1 miles west of Waiteville.....	2250′ B	None.	Reger	W. F. Prouty.
136	....	Clinton	Fossil Ore Horizon	Marine	Sweet Springs Dist., Monroe Co.; on south side of Fork Mt., 3.6 miles S. 75° W. of Waiteville.....	3280′ B	None.	Reger	W. F. Prouty.
137	....	Chemung	Hendricks Sandstone	Marine	Sweet Springs Dist., Monroe Co.; in road N. W. of bridge across Second Creek and 0.2 mi. S. E. of Red Mill.....	2275′ B	No. 7 of Gap Mills Section.	Reger	W. F. Prouty.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
138	5517	Greenbrier	Sinks Grove Limestone ...	Marine	Union Dist., Monroe Co.; in ridge road 0.1 mi.. N. W. of Mt. Hope School and 2.1 mi. east of Willow Bend.....	2290′ B	None.	Reger	G. H. Girty
139	....	Beekmantown Limestone	Probably 500 to 800′ below top.....	Marine	Sweet Springs Dist., Monroe Co.; in road at head of Dropping Lick Creek 0.4 mi. west of Zenith School and 1.5 mi. east of Zenith.....	2425′ B	None.	Reger	W. F. Prouty.
140	5518	Greenbrier	Basal 50′ of Hillsdale Limestone ...	Marine	Union Dist., Monroe Co.; in field west of road along a branch of Turkey Creek, 1.3 mi. south of Willow Bend.....	2100′ B	None.	Reger	G. H. Girty.
141	....	Portage or Chemung?	Near contact...	Marine	Sweet Springs Dist., Monroe Co.; in bed of Back Creek 2 miles N. E. of Roxalia	2275′ B	None.	Reger	W. F. Prouty.
142	....	Chemung	Hendricks Sandstone ...	Marine	Sweet Springs Dist., Monroe Co.; in road passing down east side of Cove Mt. 1.3 miles S. E. of Glace.....	2850′ B	None.	Reger	W. F. Prouty.
143	....	Chemung	Hendricks Sandstone ...	Marine	White Sulphur Dist., Greenbrier Co.; on north side of Howard Creek in bluff just north of James River and Kanawha Pike, 0.6 mile S. E. of Caldwell.....	1755′ B	No. 11 of Caldwell Section.	Reger	W. F. Prouty.
144	5519	Greenbrier	**Hillsdale Limestone; type locality**	Marine	Second Creek Dist., Monroe Co.; in road 0.1 mile E. of Hillsdale.....	2370′ B	None.	Reger	G. H. Girty
145	5520	Greenbrier	Lower part of Pickaway Limestone ...	Marine	Second Creek Dist., Monroe Co.; in road and field 0.7 mi. S. 18° E. of Monitor.	2200′ B	None.	Reger	G. H. Girty
146	5521	Greenbrier	75′ reef of Patton Limestone	Marine	Second Creek Dist., Monroe Co.; in field of Nelson Hawkins, 0.6 mi. S. E. of Pickaway	2175′ B	None.	Reger	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
147	5522	Greenbrier	Patton Shale ..	Marine and Plant	Second Creek and Union Dists., Monroe Co.; in road 0.9 mi. S. E. of Pickaway	2245′ B	None.	Reger	G. H. Girty
148	5523	Greenbrier	Sinks Grove Limestone ...	Marine	Second Creek and Union Dists., Monroe Co.; in road 0.3 mi. N. W. of Hillsdale	2245′ B	None.	Reger	G. H. Girty
149	5524	Greenbrier	Hillsdale Limestone ...	Marine	Irish Corner Dist., Greenbrier Co.; in hill road 0.3 mi. N. E. of Maple Grove School and 1.5 mi. south of Organ Cave.....	2130′ B	None.	Reger	G. H. Girty
150	5525	Greenbrier	Taggard Limestone ...	Marine	Second Creek Dist., Monroe Co.; in Pickaway-Sinks Grove road 1 mi. N. W. of Pickaway	2180′ B	Local Measurement	Reger	G. H. Girty
151	5526	Greenbrier	Union Limestone; type locality	Marine	Union Dist., Monroe Co.; in road 0.5 mi. S. W. of Union and just S. W. of high school building.....	2040′ B	None.	Reger	G. H. Girty
152	5527	Greenbrier	Taggard Limestone ...	Marine	Second Creek Dist., Monroe Co.; in high ridge road 0.8 mi. westward from Oak Grove School and 0.7 mi. S. E. of Monitor	2320′ B	None.	Reger	G. H. Girty
153	5528	Greenbrier	Hillsdale Limestone ...	Marine	Second Creek Dist., Monroe Co.; in hill road south of Second Creek and 0.5 mi. S. W. of Nickells Mill.....	2025′ B	Nos. 31, 32, and 34 of Bickett Knob Section.	Reger	G. H. Girty
154	5529	Mauch Chunk-Bluefield Group..	Ada Shale	Marine	Springfield Dist., Monroe Co.; in road on west side of Indian Creek 2.4 mi. N. E. of Raines Corner.....	1760′ B	None.	Girty and Reger.	G. H. Girty
155	5530	Greenbrier	Alderson Limestone ...	Marine	Union Dist., Monroe Co.; at quarry of Lewis McNeer on south side of Indian Creek opposite Gin Hollow and near Salt Sulphur Springs.....	1805′ B	None.	Reger	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
156	5531	Mauch Chunk-Bluefield Group..	Reynolds Limestone ...	Marine	Union Dist., Monroe Co.; in road along Turkey Creek 1.3 mi. south of Salt Sulphur Springs.....	1820' B	None.	Reger	G. H. Girty
157	5532	Mauch Chunk-Bluefield Group..	Reynolds Limestone ...	Marine	Springfield Dist., Monroe Co.; in road and bluff west of Indian Creek 2.5 mi. N. E. of Raines Corner.....	1745' B	None.	Reger	G. H. Girty
158	5533	Mauch Chunk-Bluefield Group..	Raines Corner Limestone; type locality.	Marine and Plant	Springfield Dist., Monroe Co.; in bed of Indian Creek 0.5 mi. N. W. of Raines Corner.....	1670' B	No. 27 of Wikel Section.	Reger	G. H. Girty
159	....	Mauch Chunk-Bluefield Group..	Indian Mills Shale	Plant	Springfield Dist., Monroe Co.; in bluff east of road which passes up branch of Indian Creek 0.7 mi. west of Raines Corner	1725' B	No. 24 of Wikel Section	Reger	David White.
159A	5685	Mauch Chunk-Bluefield Group..	Indian Mills Shale	Marine	Springfield Dist., Monroe Co.; in bluff east of road which passes up branch of Indian Creek 0.7 mi. west of Raines Corner	1725' B	Nos. 23 and 25 of Wikel Section.	Reger	G. H. Girty
160	5534	Mauch Chunk—Hinton Group...	Avis? Limestone	Marine	Red Sulphur Dist., Monroe Co.; on Mud Run of Rich Creek at junction of short private road with public highway 1.1 miles N. E. of Brick Church.....	1930' B	Local Measurement	Reger	G. H. Girty
161	5535	Mauch Chunk—Bluefield Group..	Coney Shale ..	Marine and Plant	Red Sulphur Dist., Monroe Co.; in bluff on west side of Brush Creek, 0.7 mi. N. E. of Peterstown.....	1690' B	Local Measurement	Reger	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
162	5536	Mauch Chunk—Bluefield Group..	Bertha Limestone	Marine	Red Sulphur Dist., Monroe Co.; in mountain road 1.1 mi. due south of Red Sulphur Springs.....	1745′ B	No. 16 of Red Sulphur Springs Section.	Girty and Reger.	G. H. Girty
163	5537	Greenbrier	Greenville Shale	Marine	Springfield Dist., Monroe Co.; in road north of Indian Creek 0.7 mi. N. W. of Greenville.....	1620′ B	None.	Reger	G. H. Girty
164	5538	Mauch Chunk—Bluefield Group..	Clayton Shale..	Marine	Springfield Dist., Monroe Co.; in hill road at head of Lowell Branch of Indian Creek 0.7 mi. S. E. of Marie.....	1970′ B	No. 4 of Marie Section.	Reger.	G. H. Girty
165	5535	Mauch Chunk—Bluefield Group..	Indian Mills Shale; type locality	Marine	Forest Hill Dist., Summers Co.; on north side of Indian Creek 0.1 mi. west of Indian Mills.....	1480′ B	No. 34 of Indian Mills Section.	Reger.	G. H. Girty
166	5540	Greenbrier	Upper portion of Alderson Limestone ...	Marine	Springfield Dist., Monroe Co.; in road along Indian Draft, 1.2 mi. south of Wayside	1645′ B	None.	Reger.	G. H. Girty
167	5541	Mauch Chunk—Bluefield Group.	Raines Corner Limestone ...	Marine	Wolf Creek Dist., Monroe Co.; in hill road 0.4 mi. S .E. of Marvin Grove School and 1.8 mi. N. E. of Wayside	2040′ B	None.	Reger.	G. H. Girty.
168	5542	Mauch Chunk—Bluefield Group..	Reynolds Limestone ...	Marine	Union Dist. Monroe Co.; in extreme top of Bickett Knob 3 mi. N. W. of Union	3330′ B	No. 4 of Bickett Knob Section.	Reger.	G. H. Girty
169	5543	Mauch Chunk—Bluefield Group..	Glenray Limestone ...	Marine	Union Dist., Monroe Co.; in N. W. slope of Bickett Knob 3.1 mi. N. W. of Union	3155′ B	No. 7 of Bickett Knob Section.	Reger.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
170	5544	Greenbrier	Upper 90′ of Alderson Limestone ...	Marine	Union Dist. Monroe Co.; in road 0.5 mi. north of Bickett Knob and 2.2 mi. S. W. of Sinks Grove.....	2935′ B	No. 9 of Bickett Knob Section.	Reger.	G. H. Girty
171	5545	Greenbrier	Lower 40′ of Alderson Limestone ...	Marine	Union Dist., Monroe Co.; in road 0.7 mi. north of Bickett Knob and 2.2 mi. S. W. of Sinks Grove.....	2895′ B	No. 10 of Bickett Knob Section.	Reger.	G. H. Girty
172	5546	Greenbrier	Upper 25′ of Union Limestone....	Marine	Union Dist., Monroe Co.; in road 0.8 mi. north of Bickett Knob and 2.2 mi. S. W. of Sinks Grove.....	2870′ B	No. 11 of Bickett Knob Section.	Reger.	G. H. Girty
173	5547	Greenbrier	Lower 125′ of Union Limestone ...	Marine	Union Dist., Monroe Co.; above and below road fork 0.9 mi. north of Bickett Knob and 2.1 mi. S. W. of Sinks Grove	2740′ B	No. 13 of Bickett Knob Section.	Reger.	G. H. Girty
174	5548	Greenbrier	Lower 65′ of Pickaway Limestone ...	Marine	Second Creek Dist., Monroe Co.; in road 1.3 mi. north of Bickett Knob and 1.7 mi. S. W. of Sinks Grove.....	2505′ B	No. 17 of Bickett Knob Section.	Girty and Reger.	G. H. Girty
175	5549	Greenbrier	Taggard Limestone ...	Marine	Second Creek Dist., Monroe Co.; in road 1.4 mi. north of Bickett Knob and 1.6 mi. S. W. of Sinks Grove.....	2480′ B	No. 19 of Bickett Knob Section.	Reger.	G. H. Girty
176	5550	Greenbrier	**Patton Limestone; 85 to 140′ below top; type collection ..**	Marine	Second Creek Dist., Monroe Co.; in ridge road 0.9 to 1.2 mi. S. W. of Sinks Grove	2400′ B	No. 22 of Bickett Knob Section.	Reger.	G. H. Girty
177	5551	Greenbrier	Lower 80′ of **Patton Limestone; type collection ....**	Marine	Second Creek Dist., Monroe Co.; in ridge road 0.7 mi. S. W. of Sinks Grove....	2265′ B	No. 24 of Bickett Knob Section.	Reger.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
178	5552	Greenbrier	Upper 45′ of Sinks Grove Limestone; type locality..	Marine	Second Creek Dist., Monroe Co.; in ridge road 0.6 mi. S. W. of Sinks Grove.....	2220′ B	No. 25 of Bickett Knob Section.	Reger.	G. H. Girty
179	5553	Greenbrier	Sinks Grove Limestone, 45 to 130′ below top; type locality	Marine	Second Creek Dist., Monroe Co.; in road and field between Sinks Grove and Spider Den School, mostly 0.1 mi. N. E. of Sinks Grove.....	2135′ B	No. 26 of Bickett Knob Section.	Reger.	G. H. Girty
180	5554	Mauch Chunk—Bluefield Group..	Reynolds Limestone; type locality	Marine	Wolf Creek Dist., Monroe Co.; in road at western edge of Swoopes Knobs plateau 0.6 mi. N. W. of Knobs village.....	.....	No. 4 of Bickett Knob Section.	Reger.	G. H. Girty
181	5555	Maueh Chunk—Bluefield Group..	Ada Shale	Marine	Wolf Creek Dist., Monroe Co.; in road on Swoopes Knobs plateau, 0.2 mi. N. W. of Knobs village.....	2915′ B	No. 3 of Bickett Knob Section.	Girty and Reger.	G. H. Girty
182	5556	Maueh Chunk—Bluefield Group..	Taleott Shale ..	Marine	Wolf Creek Dist., Monroe Co.; in private road just north of publie road on Swoopes Knobs 0.2 mile N. W. of Knobs village.....	2925′ B	No. 2 of Biekett Knob Section.	Reger.	G. H. Girty
183	5557	Mauch Chunk—Hinton Group....	Middle Bellepoint Shale; type locallty..	Marine	Greenbrier Dist., Summers Co.; on steep wooded mountain north of Greenbrier River, 0.2 mi. north of Bellepoint.....	1518′ B	Loeal Measurement	Reger.	G. H. Girty
184	5558	Mauch Chunk—Hinton Group....	Terry Limestone ...	Marine	Pipestem Dist., Summers Co.; in new road aseending Tallery Mt. west of Pipestem Creek and 2 mi. due south of True	2330′ B	No. 5 of Tallery Mt. Section.	Reger.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
185	5559	Mauch Chunk—Hinton Group....	Concy Limestone ...	Marine	Talcott Dist., Summers Co.; in hill road N. E. of Greenbrier River 1.2 mi. west of Boone School and 1.1 mi. south of Hilldale	1715′ B	None.	Reger.	G. H. Girty
186	5560	Mauch Chunk—Bluefield Group..	Raines Corner Limestone ...	Marine	Talcott Dist., Summers Co.; in road between Talcott and Bargers Springs 1.5 mi. south of Talcott.....	1725′ B	Local Measurement	Reger.	G. H. Girty
187	5561	Mauch Chunk—Bluefield Group..	Bradshaw Limestone ...	Marine	Talcott Dist., Summers Co.; in bluff south of Greenbrier River just west of Stony Creek and 0.3 mi. S. W. of Bargers Springs.....	1512′ B	Local Measurement	Girty and Reger.	G. H. Girty
188	5562	Mauch Chunk—Bluefield Group..	**Talcott Shale; type locality.**	Marine	Talcott Dist., Summers Co.; along road on south side of Greenbrier River, 0.6 mi. S. E. of Talcott.....	1515′ B	Local Measurement	Girty and Reger.	G. H. Girty
189	5563	Mauch Chunk—Hinton Group....	Pluto Shale, including Terry Limestone horizon	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 1.5 mi. S. E. of Bellepoint.....	2435′ B	No. 3 of Bellepoint Section.	Reger.	G. H. Girty
190	5564	Mauch Chunk—Hinton Group...	**Lower Pluto Shale; type collection** ...	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 1.3 mi. S. E. of Bellepoint.....	2360′ B	No. 5 of Bellepoint Section.	Reger.	G. H. Girty
191	5565	Mauch Chunk—Hinton Group....	Lower Pluto Shale	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 1.3 mi. S. E. of Bellepoint.....	2345′ B	No. 6 of Bellepoint Section.	Reger.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
192	5566	Mauch Chunk—Hinton Group....	Lower Pluto Shale	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 1.3 mi. S. E. of Bellepoint.....	2325′ B	No. 7 of Bellepoint Section.	Reger.	G. H. Girty
193	5567	Mauch Chunk—Hinton Group....	Falls Mills Limestone ...	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 1.1 mi. S. E. of Bellepoint.....	2265′ B	No. 12 of Bellepoint Section.	Reger.	G. H. Girty
194	5568	Mauch Chunk—Hinton Group....	Upper Fivemile Shale	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 1.1 mi. S. E. of Bellepoint.....	2260′ B	No. 13 of Bellepoint Section.	Reger.	G. H. Girty
195	5569	Mauch Chunk—Hinton Group....	Lower Fivemile Shale	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 1 mi. S. E. of Bellepoint.....	2226′ B	No. 15 of Bellepoint Section.	Reger.	G. H. Girty
196	5570	Mauch Chunk—Hinton Group...	Upper Tallery Shale	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 1 mi. S. E. of Bellepoint.....	2202′ B	No. 18 of Bellepoint Section.	Reger.	G. H. Girty
197	5571	Mauch Chunk—Hinton Group....	Upper Avis Shale; type collection ..	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 0.9 mi. S. E. of Bellepoint.....	2085′ B	No. 24 of Bellepoint Section.	Reger.	G. H. Girty
198	5572	Mauch Chunk—Hinton Group....	Avis Limestone; type collection	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 0.8 mi. S. E. of Bellepoint.....	2040′ B	No. 25 of Bellepoint Section.	Reger.	G. H. Girty
199	5573	Mauch Chunk—Hinton Group....	Lower Avis Shale; type collection ...	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 0.8 mi. S. E. of Bellepoint.....	2025′ B	No. 26 of Bellepoint Section.	Reger.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Sections showing Stratigraphy	Collector	Paleontologist.
200	5574	Mauch Chunk—Hinton Group....	Lower Bellepoint Shale; type locality..	Marine	Greenbrier Dist., Summers Co.; in road ascending Wolf Creek Mt., 0.2 mi. south of Bellepoint.....	1420′ B	No. 48 of Bellepoint Section.	Reger.	G. H. Girty
201	5575	Mauch Chunk—Hinton Group....	Limestone in Upper Bellepoint Shale...	Marine	Green Sulphur Dist., Summers Co.; in railroad cut on north side of Meadow Creek 0.3 mi. E. of its mouth and 0.3 mi. N. of Meadow Creek Station.....	1293′ B	Local Measurement	Reger.	G. H. Girty
202	5576	Mauch Chunk—Bluefield Group..	Middle Bellepoint Shale...	Marine	Pipestem Dist., Summers Co.; in road on west side of Pipestem Creek at foot of Tallery Mt. just south of True.....	1415′ B	No. 53 of Tallery Mt. Section.	Girty and Reger.	G. H. Girty
203	5577	Mauch Chunk—Hinton Group....	Upper Avis Shale	Marine	Pipestem Dist., Summers Co.; in new road ascending Tallery Mt. west of Pipestem Creek and 1.4 mi. south of True	1990′ B	No. 26 of Tallery Mt. Section.	Girty and Reger.	G. H. Girty
204	5578	Mauch Chunk—Bluestone Group.	Pride Shale; type locality	Marine	Plymouth Dist., Mercer Co.; at house on private road at foot of Bent Mt., 0.8 mi. S. E. of Pride.....	2550′ B	No. 8 of Pride Section.	Girty and Reger.	G. H. Girty
205	5579	Mauch Chunk—Bluestone Group.	Pipestem Shale.	Marine	Beaver Pond Dist., Mercer Co.; along Bluefield-Princeton road on north side of Brush Creek, 1 mi. N. E. of Bridge and 1.9 mi. S. W. of Princeton Station.	2425′ B	Local Measurement	Girty and Reger.	G. H. Girty
206	5580	Mauch Chunk—Bluestone Group.	Lower Belcher? Shale	Marine	Beaver Pond Dist., Mercer Co.; along Bluefield-Princeton road on west side of Brush Creek 0.5 mi. N. E. of Ceres stop and 2 mi. N. E. of Stony Gap....	2435′ B	None.	Girty and Reger.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist.
207	5581	Maueh Chunk—Bluefield Group..	Coney Shale ...	Marine	Beaver Pond Dist., Mercer Co.; in Bluefield-Princeton trolley cut 0.1 mi. S. W. of Stony Gap.....	2500′ B	No. 54 of Stony Gap Section.	Girty and Reger.	G. H. Girty
208	5582	Maueh Chunk—Bluefield Group..	Upper Graham Shale	Marine	Beaver Pond Dist., Mercer Co.; in Bluefield-Princeton road 0.2 mi. S. W. of Stony Gap.....	.....	No. 63 of Stony Gap Section.	Girty and Reger.	G. H. Girty
209	5583	Mauch Chunk—Hinton Group...	Lower Bellepoint Shale ..	Marine	Tazewell Co., Va.; in upper highway west of Bluestone River at Flattop yards, 0.2 mi. S. W. of State Line.....	2370′ B	Local Measurement	Girty and Reger.	G. H. Girty
210	5584	Maueh Chunk—Hinton Group...	Falls Mille Shale	Marine	East River Dist., Mercer Co.; in road along Fivemile Creek 4.5 mi. S. E. of Princeton and 0.9 mi. N. W. of White School	2170′ B	Local Measurement	Girty and Reger.	G. H. Girty
211	5585	Maueh Chunk—Hinton Group...	Upper Fivemile Shale; type locality	Marine	East River Dist., Mercer Co.; in road along Fivemile Creek 4.5 mi. S. E. of Princeton and 0.9 mi. N. W. of White School	2148′ B	Local Measurement	Girty and Reger.	G. H. Girty
212	5291	Maueh Chunk—Hinton Group...	Lower portion of Haekett Shale	Marine	East River Dist., Mercer Co.; in road just west of Payne Braneh of Fivemile Creek, 1.3 mi. N. W. of Oakvale.....	1895′ B	Local Measurement	Girty and Reger.	G. H. Girty
213	5586	Mauch Chunk—Hinton Group....	Upper Goodwyn Shale; type locality	Marine	East River Dist., Mercer Co.; on Fivemile Creek opposite Goodwyn Chapel and 0.9 mile N. W. of Oakvale.....	1830′ B	Local Measurement	Girty and Reger.	G. H. Girty
214	5587	Macerady	Upper part ...	Marine	Red Sulphur Dist., Monroe Co.; in road along east side of Dry Creek 0.5 mi. S. E. of Lindside.....	.....	None.	Girty and Reger.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
215	5588	Mauch Chunk—Bluefield Group..	Glenray Limestone, entire..	Marine	Wolf Creek Dist., Monroe Co.; in road at western edge of Swoopes Knobs plaateau 0.2 mi. N. E. of Reynolds School and 0.7 mi. N. W. of Knobs village.....	2860′ B	No. 7 of Elmhurst Section.	Girty and Reger.	G. H. Girty
216	5589	Mauch Chunk—Bluefield Group..	Ada Shale	Marine	Springfield Dist., Monroe Co.; in road and field on north side of Indian Creek 1.1 mi. N. W. of Raines Corner.....	.....	None.	Girty and Reger.	G. H. Girty
217	5590	Mauch Chunk—Bluefield Group..	Reynolds Limestone ...	Marine	Springfield Dist., Monroe Co.; in road on north side of Indian Creek 1.4 mi. N. W. of Raines Corner.....	1745′ B	None.	Girty and Reger.	G. H. Girty
218	5591	Greenbrier	Greenville Shale; type locality	Marine	Springfield Dist., Monroe Co.; in road on north side of Indian Creek 0.1 mi. N. W. of Hunter Spring School and 1.6 mi. S. E. of Greenville.....	1660′ B	None.	Girty and Reger.	G. H. Girty
219	5592	Mauch Chunk—Bluefield Group..	Glenray Limestone; type locality..	Marine	Talcott Dist., Summers Co.; in road and bluff on west side of Greenbrier River just north of Griffith Creek and just opposite Glenray.....	1535′ B	No. 25 of Glenray Section.	Girty and Reger.	G. H. Girty
220	5593	Mauch Chunk—Bluefield Group..	Raines Corner Limestone ...	Marine	Talcott Dist., Summers Co.; in road starting up Dempsey Mountain on south side of Griffith Creek 1.5 mi. west of Glenray	1705′ B	No. 18 of Glenray Section.	Girty and Reger.	G. H. Girty
221	5594	Mauch Chunk—Bluefield Group..	Coney Shale....	Marine and Plant	Talcott Dist., Summers Co.; in road along east side of Hungard Creek 0.5 mi. south of Clayton.....	1985′ B	No. 17 of Penee Springs Section.	Girty and Reger.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
222	5595	Mauch Chunk—Bluefield Group..	Raines Corner Limestone ...	Marine	Talcott Dist., Summers Co.; along hill road from Pence Springs to Clayton..	1555′ B	No. 40 of Pence Springs Section.	Girty and Reger.	G. H. Girty
223	5596	Mauch Chunk—Bluefield Group..	Ada Shale	Marine	Talcott Dist., Summers Co.; in bluff on west side of Greenbrier River 0.3 mi. west of Lowell.....	.....	Local Measurement	Girty and Reger.	G. H. Girty
224	5597	Mauch Chunk—Bluefield Group..	Reynolds Limestone ...	Marine	Talcott Dist., Summers Co.; in bluff on west side of Greenbrier River 0.3 mi. west of Lowell.....	1515′ B	Local Measurement	Girty and Reger.	G. H. Girty
225	5598	Mauch Chunk—Hinton Group...	Coney Shale ...	Marine	Talcott Dist., Summers Co.; in hill road just north of eastern portal of Big Bend Tunnel, 0.9 mi. W. of Talcott.....	1705′ B	No. 2 of Talcott Section.	Reger.	G. H. Girty
226	....	Pottsville—Pocahontas Group	Keystone Sandstone ...	Plant	Greenbrier Dist., Summers Co.; just S. W. of summit of Elk Knob of Keeny Mt. 0.9 mi. N. W. of Judson.....	3440′ B	Local Measurement	Reger.	David White.
226A	5684	Pottsville—Pocahontas Group	North Fork Shale	Non-Marine	Greenbrier Dist., Summers Co.; just S. W. of summit of Elk Knob of Keeny Mt. 0.9 mi. N. W. of Judson.....	3440′ B	Local Measurement	Reger.	G. H. Girty
227	....	Pocono	Middle portion?	Plant	Irish Corner Dist., Greenbrier Co.; in road south of Greenbrier River and 2.5 mi. S. W. of Ronceverte.....	1800′ B	Local Measurement	David White, Reger and Price.	David White.
228	....	Greenbrier	Patton Shale; type collection	Plant	Second Creek Dist., Monroe Co.; in road 0.8 mi. S. E. of Pickaway.....	2245′ B	None.	David White, Reger and Price.	David White.
229	....	Mauch Chunk—Bluefield Group..	Possumtrot Shale; type locality	Plant	Springfield Dist., Monroe Co.; in road on west side of Indian Creek, 1.6 mi. N. E. of Raines Corner.....	1735′ B	Local Measurement	David White, Reger and Price.	David White.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
230	....	Mauch Chunk—Bluefield Group..	Bradshaw Shale	Plant	Springfield Dist., Monroe Co.; in road on east side of Rock Camp Creek 0.6 mi. N. W. of Rock Camp.....	1800′ B	Local Measurement	David White, Reger and Price.	David White.
231	....	Greenbrier	Patton Shale...	Plant	Giles Co., Va.; in N. & W. Ry. cut on west side of New River, one-half mi. S. W. of Rich Creek.....	1545′ B	No. 18 of Lurich Section.	David White, Reger and Price.	David White.
232	....	Greenbrier	Patton Limestone ...	Plant	Giles Co., Va.; in N. & W. Ry. cut on west side of New River, one-half mi. S. W. of Rich Creek.....	1545′ B	No. 16 of Lurich Section.	David White, Reger and Price.	David White.
233	....	Greenbrier	Top of Alderson Limestone.	Plant	Giles Co., Va.; in N. & W. Ry. cut on west side of New River, 0.3 mi. S. W. of Rich Creek.....	1545′ B	No. 11 of Lurich Section.	David White, Reger and Price.	David White.
234	....	Mauch Chunk—Bluefield Group..	Upper Graham Shale	Plant	Beaver Pond Dist., Mercer Co.; along Bluefield-Princeton road 0.2 mi. S. W. of Stony Gap.....	2500′ B	No. 64 of Stony Gap Section.	David White, Reger and Price.	David White.
235	....	Mauch Chunk—Hinton Group....	**Stony Gap Sandstone; type locality..**	Plant	Beaver Pond Dist., Mercer Co.; along Bluefield-Princeton road at Stony Gap..	2510′ B	In base of No. 53 of Stony Gap Section.	David White, Reger and Price.	David White.
236	....	Mauch Chunk—Bluestone Group.	**Glady Fork Sandstone; type locality.**	Plant	Beaver Pond Dist., Mercer Co.; along Bluefield-Princeton road 1½ mi. S. W. of Princeton.....	2440′ B	None.	David White, Reger and Price.	David White.
237	....	Mauch Chunk—Hinton Group....	Terry Shale ...	Plant	Tazewell Co.; Va.; at west end of railway and highway bridges across Bluestone River 1.3 mi. N. W. of Graham..	2355′ B	Local Measurement	David White, Reger and Price.	David White.
238	....	Mauch Chunk—Hinton Group....	Terry Shale ...	Plant	East River Dist., Mercer Co.; in road along branch of Fivemile Creek 1.3 mi. N. W. of White School and 4.5 mi. S. E. of Princeton.....	2250′ B	Local Measurement	David White, Reger and Price.	David White.

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
238	....	Mauch Chunk—Hinton Group....	Terry Shale and Pluto Coal	Plant	East River Dist., Mercer Co.; in Virginian Ry. cut just north of Prineeton Station	2400′ B	Local Measurement	David White, Reger and Priee.	David White.
240	....	Mauch Chunk—Bluestone Group.	Pipestem Shale; type locality..	Plant	Pipestem Dist., Summers Co.; in Tallery Mt. road near foot of Davy Knob and 1.1 mi N. E. of Pipestem.....	2430′ B	Local Measurement	David White, Reger and Priee.	David White.
241	....	Mauch Chunk—Hinton Group....	Upper Tallery Shale; type locality	Plant	Pipestem Dist., Summers Co.; in Tallery Mt. road 1.6 mi. south of True.....	2110′ B	No. 20 of Tallery Mt. Section.	David White, Reger and Priee.	David White.
242	....	Mauch Chunk—Hinton Group....	Lower Tophet Shale	Plant	Pipestem Dist., Summers Co.; in Tallery Mt. road 0.9 mi. south of True.....	1692′ B	No. 41 of Tallery Mt. Section.	David White, Reger and Priee.	David White.
243	....	Mauch Chunk—Hinton Group....	Middle Bellepoint Shale..	Plant	Pipestem Dist., Summers Co.; in road west of Pipestem Creek just south of True	1410′ B	No. 54 of Tallery Mt. Section.	David White, Reger and Priee.	David White.
244	....	Mauch Chunk—Bluefield Group..	Cooney Shale; type locality .	Plant	Greenbrier Dist., Summers Co.; in C. & O. Ry. cut east of New River at Avis..	1410′ B	No. 67 of Hinton Section	David White, Reger and Priee.	David White.
245	5599	Mauch Chunk—Bluefield Group..	Clayton Shale; type locality..	Marine	Talcott Dist., Summers Co.; in Dempsey Mt. road south of Griffith Creek and 1.2 mi. N. E. of Clayton.....	2040′ B	No. 9 of Glenray Section.	Reger and Priee.	G. H. Girty
246	5600	Mauch Chunk—Bluefield Group..	Lillydale Shale; type collection.	Marine	Wolf Creek Dist., Monroe Co.; in field just north of Alderson-Wolf Creek road 0.8 mi. S. W. of Alderson.....	1745′ B	None.	Reger and Priee.	G. H. Girty
247	5601	Greenbrier	Alderson Limestone; type locality	Marine	Wolf Creek Dist., Monroe Co.; along Alderson-Wolf Creek road 0.3 mi. S. W. of Alderson	1615′ B	None.	Reger and Priee.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
248	5602	Mauch Chunk—Bluefield Group..	Raines Corner Limestone ...	Marine	Red Sulphur Dist., Monroe Co.; in road east of Fitz Run and just S. E. of Red Sulphur Springs town.....	1525′ B	No. 37 of Red Sulphur Springs Section.	Reger and Price.	G. H. Girty
249	5603	Mauch Chunk—Hinton Group...	Falls Mills Shale; type locality	Marine	Tazewell Co., Va.; in N. & W. Ry. cut east of Bluestone River, 0.2 mi. N. W. of Falls Mills.....	2330′ B	No. 6 of Falls Mills Section.	Reger and Price.	G. H. Girty
250	5604	Mauch Chunk—Hinton Group...	Falls Mills Limestone; type locality..	Marine	Tazewell Co., Va.; in N. & W. Ry. cut east of Bluestone River, 0.3 mi. N. W. of Falls Mills.....	2330′ B	No. 11 of Falls Mills Section.	Reger and Price.	G. H. Girty
251	5687	Mauch Chunk—Bluefield Group..	Ade Shale; type locality	Marine	Beaver Pond Dist., Mercer Co.; in road north of East River between Ada and Stony Gap and 0.2 mi. west of Ada...	2275′ B	Local Measurement	Reger.	G. H. Girty
252	5605	Mauch Chunk—Bluefield Group..	Raines Corner Limestone ...	Marine	Beaver Pond Dist., Mercer Co.; in road and field north of East River between Ada and Stony Gap and 0.4 mi. west of Ada.....	2405′ B	Local Measurement	Reger and Price.	G. H. Girty
253	5606	Mauch Chunk—Hinton Group....	Lower Bellepoint Shale...	Marine	Giles Co.; Va.; in Virginian Ry. cut on east side of New River 0.2 mi. north of Rich Creek Station and 7 ft. south of Mile-Post No. 321.....	1530′ B	Local Measurement	Reger and Price.	G. H. Girty
254	5607	Mauch Chunk—Hinton Group....	Lower Bellepoint Shale...	Marine	Red Sulphur Dist., Monroe Co.; in hill road at head of Mud Run of Rich Creek, 1.1 mi. west of Lindside.....	2085′ B	Local Measurement	Reger and Price.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Continued)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Paleontologist
255	5608	Mauch Chunk—Bluefield Group..	Glenray Limestone ...	Marine	Springfield Dist., Monroe Co.; along old mill race on east side of Rock Camp Creek 0.6 mi. S. E. of Rock Camp....	1875′ B	None.	Reger and Price.	G. H. Girty
256	5609	Greenbrier	Taggard Limestone; type locality..	Marine	Union Dist., Monroe Co.; in road just north of Taggard Branch of Indian Creek 2.8 mi. S. E. of Union.....	2035′ B	Local Measurement	Reger and Price.	G. H. Girty
257	....	Greenbrier residual clay....	.....	Vertebrate bones	Beaver Pond Dist., Mercer Co.; in N. & W. Ry. yards 1.3 mi. S. W. of Bluefield Station.....	2480′ B	None.	Reger and W. R. Crenshaw	.....
294	5676	Pocono	Broad Ford Sandstone ...	Marine	Beaver Pond Dist., Mercer Co.; on a short branch of East River 0.4 mi. S. E. of Bluefield water pumping station and 1 mi. S. W. of Ada.....	2320′ B	No. 95 of Stony Gap Section.	Reger.	G. H. Girty
295	5660	Greenbrier	Union Limestone, Fredonia portion	Marine	Beaver Pond Dist., Mercer Co.; in N. & W. Ry. cut 1 mi. west of Ada.....	2340′ B	No. 86 of Stony Gap Section.	Reger.	G. H. Girty
296	5677	Pocono	Sunbury Shale..	Marine	Beaver Pond Dist. Mercer Co.; on east side of Bland St., Bluefield, about 800′ south of post-office.....	2575′ B	No. 15 of Bluefield Section.	Reger.	G. H. Girty
297	5678	Pocono	Broad Ford Sandstone ...	Marine	Red Sulphur Dist., Monroe Co.; along Rich Creek road 0.9 mi. S. E. of Brick Church	1870′ B	No. 14 of Brick Church Section.	Reger.	G. H. Girty
298	5659	Greenbrier	Union Limestone, basal 50′ of Fredonia portion.	Marine	Union Dist., Monroe Co.; half-mile outcrop along syncline one-third mile west of Union	.....	None.	Reger.	G. H. Girty
.....	628	Greenbrier	Union Limestone	Marine	Beaver Pond Dist., Mercer Co.; in N. & W. Ry. cut chiefly 1½ to 2 mi: northeast of Bluefield, W. Va., station.....	.....	No. 86 of Stony Gap Section.	David White, and G. H. Girty.	G. H. Girty

List of Fossil Localities, Mercer, Monroe and Summers Counties (Concluded)

Lot Number W. Va. G. S.	Lot Number U. S. G. S.	Geologic Series	Member or Zone	Kind of Fossils	Location	Elevation above Sea-Level	Measured Section showing Stratigraphy	Collector	Palcontologist
.....	629	Mauch Chunk—Hinton Group....	Lower portion..	Marine	Beaver Pond Dist., Mercer Co.; W. Va., and Clear Fork Dist., Tazewell Co., Va., in N. & W. Ry. cut at Flattop Yards..	.....	None.	David White and G. H. Girty.	G. H. Girty
.....	630	Mauch Chunk—Bluefield Group..	Lower portion..	Marine	Beaver Pond Dist., Mercer Co.; in N. & W. Ry. cut just south of Abbs Valley..	.....	Probably ranges through most of Nemours Station Section.	David White and G. H. Girty.	G. H. Girty
.....	631	Mauch Chunk?—Bluefield Group?.	.....	Marine	Beaver Pond Dist., Mercer Co.; in N. & W. Ry. cut about one-half mile from Abbs Valley.....	.....	None.	David White and G. H. Girty.	G. H. Girty
.....	633	Mauch Chunk?—Bluefield Group?.	.....	Marine	Beaver Pond Dist., Mercer Co.; in N. & W. Ry. cut east of Lot 631.....	.....	None.	David White and G. H. Girty.	G. H. Girty
.....	3221	Greenbrier	Upper part....	Marine	Beaver Pond Dist., Mercer Co.; northwest of Nemours and north of quarry..	.....	None.	Girty.	G. H. Girty

GENERAL FEATURES OF THE MISSISSIPPIAN FLORAS OF THE APPALACHIAN TROUGH.

By David White.

Relatively little has been published regarding the Mississippian floras of the United States. No fresh-water or estuarine swamp deposits of considerable thickness and extent favorable for containing fossil plants are present, with the exception of the Pocono formation. The paleontology of the Mississippian formation has, for the most part, been pursued by students of invertebrates who have taken little interest in the plant-bearing deposits and have neglected to collect specimens for study, and, finally, Mississippian plant fossils are generally so scarce and fragmentary that paleobotanists have concentrated their attention on the profusely rich and fascinating plant life of the Pennsylvanian and Permian formations. Some of the specimens, notably those from the deposits near Newark, Ohio, in Orange County, Indiana, and in western Illinois, described by Andrews and Lesquereux as coming from beds of Chester age, have been found, as the result of the examination of the Pottsville floras, to belong to the lower Pennsylvanian.

The materials examined consist of plants growing on soils under terrestrial conditions, though many of them are undoubtedly native to a swamp environment. In the latter case, however, the waters in the swamps were fresh. Fossil algae have in general been given relatively little attention, due to the fragmentary condition and the consequent difficulty of determining those with non-resistant or even somewhat gelatinous fronds. The Mississippian, nevertheless, contains many types of algae, some of which present characters easily recognized and qualifying them for use in correlation by the stratigraphic geologist. The study of the fossil calcareous algae is still in its infancy, for the importance of these plants in their function of rock building has only in late years received growing recognition. They offer an inviting and profitable field for study.

The Mississippian formations of the Appalachian trough embrace two relatively distinct floras which are fairly clearly defined, though each comprises one or more subordinate floras. The two floras belong to the Upper and Lower divisions of the system. The earlier flora is represented mainly by the plant life of the Pocono and may be referred to as the "Pocono" type, while the later flora may be collectively designated as representing the "Chester" type.

Lower Mississippian Flora or Pocono Type.

The flora of the Pocono formation itself is unique on account of the very limited number of genera and even of species composing it. The vegetation in the broad Pocono swamps was relatively luxuriant. It occupied its habitat for a long time, and many of the types were of large size, some of the fern-like plants being arborescent in stature. The relative paucity of species is presumably due to the extermination of most of the plant life previously occupying the region and the newness of some of the genera.

Most of the specimens found associated with the coals and shales of the Pocono belong to the genera **Triphyllopteris, Lepidodendron,** and **Sphenopteris.** Both in **Triphyllopteris** and in **Lepidodendron** the species were remarkable for their polymorphy—that is, for the variability of their characters. In fact these two genera seem to have been in a plastic stage during Pocono time, with the result that each species varies so widely in its character that, with a large amount of material spread before the paleobotanist, it is difficult either to divide it with reasonable satisfaction into a number of species, or, on the other hand, to refer the variations to a single species. This is particularly true, with the species of the newly formed genus **Triphyllopteris,** in which indubitably a number of species are present, including **T. alleghaniensis, T. Lescuriana** (Meek) Font., and **T. Virginiana** Meek, though in some cases intermediate forms difficult to refer to one species or another furnish unmistakable evidence of the activity of evolution in this genus during Pocono time. Some of these variants verge into the genus **Aneimites.**

The specimens of **Lepidodendron,** which in some beds practically monopolize the habitat, are, for the most part, at least, referable to **L. scobiniforme** Meek, which is most closely related to **L. corrugatum** of Dawson.

With **Triphyllopteris** and **Lepidodendron** there are nearly everywhere present fragments of an extremely graceful and attenuated species of **Sphenopteris** of very lax habit, first identified as **S. flaccida** Crepin, but to which I have given the name **Sphenopteris vespertina.** Also, forms closely related to **S.** frigida from the Arctic Mississippian, and **S. Schimperiana** of western Europe, are present.

Representatives of the Paleozoic family **Calamariae** are little in evidence in the Pocono flora. The genus **Calamites** does not appear to have originated.

The Pocono flora is markedly distinct from the Catskill flora. The latter is rich in a variety of species of **Archaeopteris,** some of which evidently were very beautiful and graceful. No species of **Archaeopteris** has yet been found in the Pocono, and **Triphyllopteris,** on the other hand, is not present in the American Devonian. The Lepidodendra of the Pocono are, however, clearly derived from the Devonian stock illustrated, for example, by **L. Gaspianum** Dawson, and apparently represent the last phase of this type, all species of which are characterized by such an arrangement of the leaf scars (phyllotaxy) as to bring the bolsters into nearly vertical longitudinal alignment, with a nearly transverse lateral arrangement that sometimes produces a false appearance of nodes. The Sphenopterids of the Pocono are, on the other hand, referable to a group of deeply dissected and generally delicate fern-like plants found in the Bear Island series of the Arctic regions from Alaska to Spitzbergen, in the lower Mississippian of Western Europe, and in the Calciferous sandstone series of Scotland, in all of which regions **Triphyllopteris** or **Aneimites** also is present.

The Pocono flora is notably homogeneous and relatively uniform in its character throughout the geographical extent of the formation from northeastern Pennsylvania to the Virginia-Tennessee line, where it is present, associated with coaly streaks, in beds formerly referred to the Grainger. The dis-

tinctness of this flora from that of the Devonian seems to reflect the changes in the environment. Minor diastrophic movements had raised the land above tide level throughout the extent of these deposits, while, at the same time, mountain building, probably to the east, promoted the outwash of great amounts of white and gray grits and gravels which compose the greater part of the formation. Some reworking of greenish and reddish Catskill material is found in the basal beds. Thus, in the northern Appalachian trough the beginning of Mississippian sedimentation is marked both by terrestrial movements above an unconformity, and by strongly contrasting changes in the plant life.

As belonging in a general way to the Pocono type of flora, mention must be made of the occurrence at a number of localities of fragments typically representing **Aneimites**, a genus evidently related to **Triphyllopteris** if not derived directly from it, but differing somewhat in its habit of growth. The stratigraphic relations of the **Aneimites**-bearing beds on Big Loyalsock Creek, west of Bernice, Pennsylvania, northwest of Tyrone in the same State, and between Pickens and Webster Springs in West Virginia, seem not to have been definitely determined, but it is probable that the distinctly **Aneimites** flora, which as yet is known only from scarce and fragmentary specimens, belongs stratigraphically not far above the typical Pocono. It is not unlikely that the **Aneimites** remains were laid down on littoral terranes marking a brief exposure of the land succeeding the submergence of the Pocono beds.

Upper Mississippian Flora or Chester Type.

The plant life of the Upper Mississippian, mainly found in formations referred to the Chester group, is fully as distinct from the Pocono type as the latter is from the Devonian (Catskill). In its general aspect this flora is much nearer to the Pennsylvanian plant development, from which, however, it is, in general, distinguished with great ease. Only in the youngest terranes of the Mississippian as developed in those areas where, as near Bluestone Junction, West Virginia,

there is little or no evidence of the interruption of sedimentation in passing from Mississippian to Pennsylvanian time, do we find fern-like species so similar to some of those found in the Lower Pennsylvanian as to make paleobotanical distinction difficult.

The Chester flora is one of wide extent. In its principal features it is closely comparable to the plant life of the "Carboniferous limestone series" of central or western Europe. In fact, though conditions favoring the preservation and study of this flora appear to have been very restricted, the flora is nevertheless cosmopolitan.

The salient components of the Chester type of flora are Lepidodendra of the type of **Lepidodendron Volkmannianum** Sternb., together with early representatives of the group with narrow lanceolate bolsters in distinctly spiral arrangement. The Volkmannianum stock is parent of the Pennsylvanian **L. Wortheni** Lx. and **L. Brittsii** Lx. In this flora we find several delicate forms of **Sphenopteris,** with extremely narrow pinnules, and here appear also certain branching sphenopteroid fronds with short tripartite pinnules, generally coriaceous, that are evidently ancestral to the **Sphenopteris Hoeninghausii** group.

Calamarian remains of the form known as **Asterocalamites scrobiculatus (Bornia radiata)** are typical of the Chester, though in the highest beds early forms referable to **Calamites** make their appearance.

Most characteristic of the Chester flora is the presence of representatives of the genus **Cardiopteris,** a well-known intercontinental genus of the Upper Mississippian. Most of the American specimens are apparently referable to **C. polymorphia** (Goepp.) Schimp., an Old World species.

Accompanying the remains of **Lepidodendron,** especially in the clays underlying thin coal-seams, are found numerous specimens of the form of Stigmaria described as **Stigmaria ficoides stellata.** This root is in fact as characteristic, perhaps, of the Chester as is **Lepidodendron Volkmannianum,** to which it possibly was attached. Only in the youngest of the Mississippian sediments may be met early Neuropterids,

foreshadowing the **Neuropteris Schlehani** type and forms of somewhat Alethopteroid facies.

From the foregoing it will be seen that the flora of the earlier Mississippian is readily distinguishable from the Catskill flora, especially if the comparison is confined to the fern-like components. On the other hand, the younger Mississippian plants are clearly distinguished from those of the Pennsylvanian, except where the very latest Mississippian happens to be present, as is seldom the case. In general, the Chester-Pennsylvanian line is very sharply drawn paleobotanically, for in most portions of the Appalachian trough the lower Pottsville is absent.

Conclusions as to the systematic biological relations of the Mississippian floras are based largely upon deduction and inference. The early representatives of the **Sphenopteris Hoeninghausii** group undoubtedly belonged to the Cycadofilices or Pteridosperms, a remarkable Paleozoic stock combining the habit and foliar characteristics of ferns, with a primitive form of inflorescence and the production of seeds similar to those of some of the lower groups of gymnosperms. **Triphyllopteris** and its close relative, **Aneimites**, almost certainly represent an early phase of the Neuropteroid class which forms another branch of the Cycadofilices, some of the large seeds of which are known as **Rhabdocarpos** and **Trigonocarpum.** Pottsville descendants of the Mississippian forms described as **Aneimites** and **Adiantites** have been found with with their small seeds still attached to fern-like fronds.

Reference has already been made to the highly probable Neuropteroid connection of **Cardiopteris.** Though the Paleozoic Lepiodendroid representatives of the great Lycopod stock are much in evidence, no fern-like plant confidently referable to the true ferns is known in the older flora. Further, it is certain that genuine ferns are rare in the later Mississippian floras, though it is possible that some of the extremely delicate forms of **Sphenopteris,** apparently related to spore-bearing species of the Pennsylvanian, are likewise to be classed as ferns. The genus **Pecopteris**, which includes a great variety of species in the Pennsylvanian flora, including

many ferns of arborescent proportions, does not appear to be represented in the plant life of the Mississippian.

In the foregoing paragraphs attention is given only to the general characters of composition of the Mississippian floras, with remarks on their broad geographic distribution and their mass relations to the succeeding and following floras. The detailed discussion of the distribution, both geographical and vertical, of the genera and species, and the conclusions as to questions of correlation and contemporaneity, are left to accompany the full description of the different floras.

CHAPTER XVIII.

INVERTEBRATE PALEONTOLOGY.

INTRODUCTION.

By David B. Reger.

As previously stated in this Report Dr. George H. Girty, Geologist, United States Geological Survey, and an eminent authority on the Carboniferous faunas of the United States, has most kindly undertaken the identification and discussion of the Mississippian invertebrate collections of Mercer, Monroe, and Summers Counties, as well as certain others made by the writer in other counties and States in the course of special studies on correlation. The work of Dr. Girty was designed to include not only the identification of common or known forms but also the systematic description of new species and the illustration of new or unusually good, or otherwise important, specimens which are of prime value in the study of these rocks.

In the local area 130 collections have been made of Carboniferous invertebrates, including one from the Pottsville Series of the Pennsylvanian and 129 from the various groups of the Mississippian. These were mainly made by the writer in the course of stratigraphic studies but Dr. Girty himself spent a week in the field in review of the faunas in place and in amplification of certain collections; and some further valuable help was obtained from Mr. Paul H. Price of the West Virginia Survey Staff during a three weeks' trip, and from Dr. William F. Prouty in an incidental way during his studies of the Devonian and older rocks. A few others made independently in former years by Drs. Girty and David White should also be mentioned. The collections should not be considered as exhaustive and complete at the various localities, since a choice had to be made between a few minutely worked

localities and a greater number of collections distributed more widely over the area under study. In view of the fact that many formations or members examined were new and almost entirely unknown the latter alternative was chosen in the belief that more diagnostic and representative faunas could be secured, as it was thereby possible to note the repeated occurrence of any species, or assemblage of species, in a particular member.

In Chapters V-IX, inclusive, dealing with Stratigraphy, all these Carboniferous marine collections were mentioned and the lists and discussions by Dr. Girty in the present Chapter were called for, but after these five Chapters on Stratigraphy had been printed it was found, most unfortunately, that the limited time which Dr. Girty could give to the West Virginia Survey was insufficient to permit the preparation of all the data. Consequently, instead of the full lists of faunas, illustrations, and descriptions of new or important species, and discussions, it is now possible to publish in most instances only one collection from each fossiliferous member, without attendant illustrations and discussions. Under this arrangement the type locality, or the most representative local collection as the case may be, has been selected. In most cases, however, the class names are available and have been already used in the Chapters on Stratigraphy.

In a future volume, devoted exclusively to the Mississippian of the Appalachian States, and, undertaken with the purpose of definitely correlating rocks of this age in West Virginia with their counterparts in other States, it is expected that all these collections in the three counties herein studied, together with those made by the writer in the course of the investigation in other counties and States, will be fully presented, with adequate illustrations and discussions by Dr. Girty.

Following the faunas identified by Dr. Girty from collections at type or representative localities of the Pennsylvanian and Mississippian in the local area will be found, in this Chapter, a discussion of the Devonian, Silurian, and Ordovician faunas by Dr. William F. Prouty of the University of North

Carolina and lately Paleontologist on the West Virginia Geological Survey Staff. In the season of 1922 Dr. Prouty spent three or four weeks with the writer in the examination of the faunas of these Pre-Carboniferous rocks and hence his knowledge of their contents is first-hand. Altogether, including the collections made later in the season by the writer, Dr. Prouty has had available for study 102 collections from the stratigraphic limits above mentioned. In Chapters V, X, XI, and XII the stratigraphy of these beds has been discussed by the writer, the fossil identifications of Dr. Prouty being inserted in the detailed sections where they belonged. The paper of Dr. Prouty in the present Chapter, therefore, is in the nature of a critical review of the more important faunas and points of correlation.

With the possible exception of the upper part of the limestone assigned to the Stones River in Chapter XII, in which Dr. Prouty has identified certain Chambersburg species and therefore feels inclined toward the local recognition of that formation but which the writer believes can be accounted for by a local upward range of the species, there have been only trifling differences of opinion. The correlations of the Devonian, Silurian, and Ordovician, although written and discussed by the writer, are naturally much influenced by the views of Dr. Prouty, as is herein cheerfully acknowledged.

List of Fossil Localities.—In Chapter XVII, pages 803-836 there is published a List of Fossil Localities, including not only the plant collections now in the possession of and under study by Dr. David White, but also the Pennsylvanian and Mississippian invertebrate collections in the hands of Dr. Girty, and the Devonian, Silurian, and Ordovician faunas as reported and discussed by Dr. Prouty. This list includes all collections in the three counties or bordering localities but does not include certain others made in more distant territory and not pertinent to this Report.

The advance fossil lists by Dr. Girty and the discussion by Dr. Prouty, respectively, are as follows:

FAUNAS OF THE PENNSYLVANIAN AND MISSISSIPPIAN PERIODS.

By George H. Girty.

POCAHONTAS GROUP OF POTTSVILLE SERIES—PENNSYLVANIAN.

North Fork Shale—Lot 226A.

Naiadites elongatus
Numerous ostracods.

BLUESTONE GROUP OF MAUCH CHUNK SERIES—MISSISSIPPIAN.

Lower Belcher Shale?—Lot 206.

Edmondia equilateralis
Allerisma Andrewsi?
Parallelodon aff. micronema
Spathella? sp.
Caneyella Richardsoni.

Pipestem Shale—Lot 205.

Nucula sp.
Cypricardella aff. oblonga.

Pride Shale—Lot 204 (Type Locality).

Orthoceras sp.

HINTON GROUP OF MAUCH CHUNK SERIES—MISSISSIPPIAN.

Terry Limestone—Lot 126.

Fenestella sp.
Archimedes aff. negligens
Orthotetes Kaskaskiensis
Diaphragmus elegans
Spiriferina spinosa
Composita subquadrata
Cliothyridina sublamellosa
Eumetria vera
Edmondia? sp.
Schizodus sp.
Aviculipecten Morrowensis
Myalina subacuta n. sp.
Conocardium sp.
Griffithides mucronatus?

Pluto Shale and Terry Limestone—Lot 189.

Fenestella sev. sp.
Polypora sp.
Orthotetes? sp.
Productus ovatus
Productus inflatus var.
Avonia Arkansana
Diaphragmus elegans
Camarophoria explanata
Spiriferina spinosa
Reticularia setigera
Composita subquadrata
Cliothyridina sublamellosa
Eumetria vera
Solenomya sp.
Allerisma? sp.
Leda suspecta n. sp.
Schizodus sp.
Aviculipecten aff. Tahlequahensis
Aviculipecten aff. Jenneyi
Euconospira sp.

Lower Pluto Shale—Lot 190 (Type Collection).

Spirorbis sp.
Lingulidiscina sp.
Productus ovatus?
Allerisma n. sp.
Solenomya? sp.
Nucula Randolphensis
Leda suspecta n. sp.
Yoldia sp.
Schizodus sp.
Deltopecten Campbellianus n. sp.
Aviculipecten aff. Tahlequahensis
Myalina Welleriana
Bucanopsis aff. Meekiana
Euphemus Randolphensis?
Aclisina aff. quadricarinata.

Falls Mills Shale—Lot 249 (Type Locality).

Myalina prolifica n. sp.
Ostracoda indet.

Falls Mills Limestone—Lot 250 (Type Locality).

Spirorbis sp.
Myalina prolifica n. sp.
Ostracoda indet.

Upper Fivemile Shale—Lot 211 (Type Locality).

Streblotrypa sp.
Spirifer sp.
Spiriferina spinosa

Sphenotus sp.
Nucula platynotus?
Leda innumeralis n. sp.?
Aviculipecten aff. Tahlequahensis
Myalina subacuta n. sp.
Leptodesma Spergenense.

Lower Fivemile Shale—Lot 195.

Spirorbis sp.
Myalina prolifica n. sp.
Ostracoda indet.

Upper Tallery Shale—Lot 196.

Spirorbis sp.
Sphenotus sp.
Nucula sp.
Leda sp.
Myalina subacuta n. sp.

Upper Avis Shale—Lot 197 (Type Collection).

Leda innumeralis n. sp.
Deltopecten Campbellianus n. sp.
Myalina subacuta n. sp.
Euphemus Randolphensis
Ostracoda indet.

Avis Limestone—Lot 198 (Type Collection).

Triplophyllum sp.
Agassizocrinus sp.
Fistulipora sp.
Stenopora Miseri?
Fenestella tenax
Fenestella sev. sp.
Polypora sev. sp.
Septopora subquadrans
Orthotetes Kaskaskiensis
Streptorhynchus? sp.
Diaphragmus elegans
Camarophoria explanata
Spirifer Pellensis var.
Spiriferina transversa
Spiriferina spinosa
Composita subquadrata
Cliothyridina sublamellosa
Eumetria vera
Allerisma clavatum
Solenomorpha nitida
Schizodus sp.
Deltopecten bellistriatus n. sp.?
Cypricardella sp.
Bellerophon sp.
Griffithides sp.

Lower Avis Shale—Lot 199 (Type Collection).

Orthotetes Kaskaskiensis
Productus ovatus
Diaphragmus elegans
Composita subquadrata
Allerisma Walkeri?
Solenomya? n. sp.
Sphenotus aff. Monroensis
Nucula Randolphensis?
Leda sp.
Schizodus depressus?
Aviculipecten aff. Tahlequahensis
Pteronites aff. laevis
Myalina subacuta n. sp.?
Myalina Welleriana
Aclisina sp.
Ostracoda indet.

Hackett Shale—Lot 212.

Spirorbis sp.
Lingula aff. Batesvillae
Sphenotus gracilis n. sp.
Sphenotus aff. Monroensis
Deltopecten bellistriatus
Myalina subacuta n. sp.
Schizodus sp.
Ostracoda indet.

Upper Goodwyn Shale—Lot 213 (Type Locality).

Lingula Batesvillae?
Myalina subacuta n. sp.
Ostracoda indet.

Upper Bellepoint Shale—Lot 201.

Sphenotus? sp.
Myalina prolifica n. sp.
Ostracoda indet.

Middle Bellepoint Shale—Lot 183 (Type Locality).

Spirorbis sp.
Sphenotus? sp.
Myalina prolifica n. sp.
Ostracoda indet.

Lower Bellepoint Shale—Lot 209.

(The type locality represented by Lot 200 has furnished so meager a fauna that it seemed best to substitute another collection).

Productus ovatus
Diaphragmus elegans
Nucula platynotus?
Leda suspecta n. sp.
Yoldia sp.
Deltopecten bellistriatus n. sp.
Myalina prolifica n. sp. ?
Leptodesma carboniferum
Schizodus depressus?
Aclisina aff. quadricarinata.

BLUEFIELD GROUP OF MAUCH CHUNK SERIES—MISSISSIPPIAN.

Coney Shale—Composite List of Lots 122, 161, 185, 207, 221, and 225.

(Each lot contains a very small fauna and all the faunas are similar to one another. No invertebrate collection at type locality).

Spirorbis sp.
Diaphragmus elegans
Martinia? sp.
Composita subquadrata
Cliothyridina sublamellosa
Sphenotus aff. Monroensis
Myalina prolifica n. sp.
Aviculipecten sp.
Cycloceras sp.
Leaia n. sp.
Ostracoda indet.

Clayton Shale—Lot 245 (Type Locality).

Spirorbis sp.
Sphenotus sp.
Myalina prolifica n. sp.

Graham Limestone—Lot 123 (Part) (Type Locality).

(See note on Upper Graham Shale).

Productus ovatus
Diaphragmus elegans
Spirifer increbescens
Composita subquadrata
Nucula platynotus
Bucanopsis aff. Meekiana.

Upper Graham Shale—Lot 123 (Part) (Type Locality).

[This collection comprises the Graham Limestone and the Upper Graham Shale mixed. I have separated this col-

lection into two parts, though rather insecurely. The shale collection especially is almost identical in its fauna and in its rock characters with our collections from the cuts near Nemours (Abbs Valley) which are referred to the Lillydale Shale. Is there a mistake somewhere or is this merely a remarkable recurrence?—G. H. G.]

("On your notation concerning Lot 123 I know of nothing that I could add in the way of information except to recall that there was a rather varied fauna at this locality. It is possible that it might have been mixed with Lot 14 which was made in the Glenray Limestone about one-half mile farther southeast and which I think was lost for a time but finally turned up. I know of nothing much to do with Lot 123 except to let it stand as we now have it."—Letter of D. B. R. to G. H. G.)

Stenopora sp.
Lingulidiscina sp.
Allerisma sp.
Sphenotus aff. Monroensis
Nucula platynotus
Leda innumeralis n. sp.
Yoldia perampla n. sp.
Schizodus depressus
Deltopecten Campbellianus n. sp.
Myalina subacuta n. sp.
Myalina prolifica (n. sp.)?
Myalina sanctiludovici?
Leptodesma sp.
Plagioglypta aff. annulistriata
Bucanopis aff. Meekiana
Euphemus Randolphensis
Pleurotomaria? n. sp.
Phanerotrema n. sp.
Aclisina aff. quadricarinata
Sphaerodoma aff. micula
Orthoceras sp.
Cycloceras Whiteanum n. sp.
Nautilus sp.
Ostracoda indet.

Bertha Limestone—Lot 152.

Stenopora sp.
Orthotetes Kaskaskiensis
Diaphragmus elegans
Spirifer increbescens
Composita subquadrata
Allerisma clavatum
Sphenotus sp.
Nucula? sp.
Leda Vaseyana?
Deltopecten bellistriatus (n. sp.)

Bradshaw Limestone—Lot 187.

Orthotetes Kaskaskiensis
Diaphragmus elegans
Composita subquadrata
Eumetria vera
Allerisma sp.
Nucula platynotus?
Leda sp.
Aviculipecten sp.
Myalina prolifica n. sp.

Indian Mills Shale—Lot 165 (Type Locality).

Sphenotus sp.
Anthraconeilo? sp.
Myalina prolifica n. sp.
Ostracoda indet.

Raines Corner Limestone—Lot 158 (Type Locality).

Productus ovatus
Camarophoria explanata
Spirifer Pellensis
Composita subquadrata
Eumetria Verneuiliana
Allerisma Walkeri
Sphenotus Monroensis
Nucula sp.
Deltopecten Wyandotte?
Myalina? sp.
Bellerophon sp.

Talcott Shale—Lot 188 (Type Locality).

Fistulipora sp.
Orthotetes Kaskaskiensis var.
Productus ovatus
Pustula? sp.
Diaphragmus elegans
Spirifer Pellensis
Spiriferina spinosa
Composita sp.
Cliothyridina sublamellosa
Eumetria Verneuiliana
Allerisma sp.
Sphenotus sp.
Nucula platynotus
Leda Vaseyana?
Yoldia n. sp.
Parallelodon sp.
Schizodus depressus var. abruptus
Deltopecten Batesvillensis?
Aviculipecten sp.
Myalina elongata
Orthoceras sp.
Cycloceras aff. Ballianum
Pseudorthoceras? sp.

Ada Shale—Lot 251 (Type Locality).

Stenopora sp.
Fenestella tenax
Fenestella sp.
Polypora sp.
Productus ovatus
Pustula sp.
Diaphragmus elegans
Dielasma sp.
Camarophoria explanata
Spirifer Pellensis
Spiriferina spinosa
Spiriferina transversa
Reticularia setigera
Composita subquadrata
Cliothyridina sublamellosa
Eumetria Verneuiliana
Deltopecten aff. Batesvillensis
Aviculipecten aff. interlineatus
Aviculipecten aff. McCoyi
Aviculipecten aff. Monroensis
Aviculipecten aff. Tahlequahensis.

Reynolds Limestone—Lot 180 (Type Locality).

Triplophyllum sp.
Archimedes sp.
Orthotetes Kaskaskiensis
Productus ovatus
Diaphragmus elegans
Spirifer Pellensis
Composita trinuclea
Allerisma sp.
Griffithides sp.

Glenray Limestone—Lot 219 (Type Locality).

Fenestella tenax
Fenestella sp.
Archimedes Proutanus var.
Polypora sp.
Rhombopora sp.
Productus ovatus
Diaphragmus elegans
Girtyella? sp.
Spirifer Pellensis
Spiriferina spinosa
Composita sulcata?

Lillydale Shale—Lot 246 (Type Collection).

Fistulipora sp.
Stenopora tuberculata?
Fenestella sev. sp.
Archimedes sp.
Polypora sp.

Septopora subquadrans
Rhombopora sp.
Crania aff. levis
Orthotetes Kaskaskiensis
Productus inflatus
Productus ovatus
Pustula? sp.
Diaphragmus elegans
Girtyella sp.
Spirifer Pellensis
Spiriferina spinosa
Spiriferina transversa
Reticularia setigera
Composita subquadrata
Eumetria Verneuiliana
Edmondia nucleus n. sp.
Edmondia sp.
Nucula sp.
Leda suspecta n. sp.
Yoldia sp.
Schizodus depressus var. abruptus
Cypricardinia Indianensis?
Deltopecten marginalis?
Aviculipecten Monroensis
Aviculipecten sp.
Aviculipecten sp.
Myalina elongata
Leptodesma sp.
Conocardium sp.
Cypricardella semirugosa n. sp.
Cypricardella sp.
Bellerophon sublevis
Phanerotrema n. sp.
Pleurotomaria aff. spironema
Orthoceras sp.
Nautilus sp.
Griffithides mucronatus?
Ostracoda indet.

GREENBRIER SERIES—MISSISSIPPIAN.

Alderson Limestone—Lot 247 (Type Locality).

Triplophyllum Pellense
Pentremites sp.
Crinoid indet.
Fistulipora sp.
Stenopora Miseri?
Fenestella tenax
Fenestella sev. sp.
Archimedes terebriformis
Archimedes Proutanus var.
Polypora sp.
Rhombopora sp.
Orthotetes Kaskaskiensis
Productus ovatus
Diaphragmus elegans
Girtyella Indianensis?
Spirifer Pellensis

Spiriferina spinosa
Spiriferina transversa
Composita trinuclea?
Cliothyridina sublamellosa
Eumetria Verneuiliana
Edmondia? sp.
Sphenotus aff. Washingtonensis
Parallelodon minimus?
Aviculipecten aff. Batesvillensis
Aviculipecten sp.
Aviculipecten sp.
Myalina? sp.
Schizodus sp.
Capulus Chesterensis?

Greenville Shale—Lot 218 (Type Locality).

Caneyella Wapanuckensis
Caneyella nasuta
Caneyella nasuta var.
Caneyella percostata?
Orthoceras sp.

Union Limestone—Lot 151 (Type Locality).

Triplophyllum Pellense
Pentremites Godoni
Pentremites pyriformis
Pterotocrinus aff. serratus
Fistulipora sp.
Stenopora Miseri?
Fenestella tenax
Archimedes sp.
Glyptopora? sp.
Chonetes sericeus
Productus inflatus
Productus ovatus
Pustula Moorefieldana var. pusilla
Diaphragmus elegans
Camarophoria explanata
Girtyella brevilobata
Spirifer Pellensis
Spirifer aff. striatus
Reticularia setigera
Brachythyris Ozarkensis?
Spiriferina transversa
Composita sp.
Cliothyridina sublamellosa
Eumetria Verneuiliana
Griffithides sp.

Pickaway Limestone—Lots 114 and 115.

Triplophyllum Pellense
Platycrinus Huntsvillae
Stenopora Miseri?
Fenestella tenax
Fenestella sp.

Septopora sp.
Crania aff. levis
Schizophoria n. sp.
Productus ovatus
Productus inflatus
Productus parvus
Diaphragmus elegans
Pugnoides sp.
Dielasma Illinoisense?
Spirifer Pellensis
Reticularia setigera
Composita trinuclea.

Taggard Limestone—Lot 256 (Type Locality).

Pentremites Godoni
Girtyella Indianensis
Spirifer Pellensis
Composita trinuclea
Cliothyridina sublamellosa
Eumetria Verneuiliana.

Patton Limestone—Lots 176 and 177 (Type Collections).

Triplophyllum Pellense
Pentremites sp.
Platycrinus Huntsvillae
Fistulipora sp.
Fenestella tenax
Schizophoria n. sp.
Orthotetes Kaskaskiensis?
Productus sp.
Productus parvus
Pustula Genevievensis
Pustula sp.
Diaphragmus elegans
Girtyella Indianensis?
Spirifer Pellensis?
Reticularia setigera
Composita sp.
Cliothyridina sublamellosa
Solenospira sp.
Griffithides sp.

Patton Shale—Lot 147 (Type Collection).

Pentremites florealis
Platycrinus? sp.
Fistulipora sp.
Stenopora Miseri?
Fenestella sp.
Productus ovatus
Productus parvus
Pustula biseriata
Pugnoides Ottumwa
Girtyella? sp.
Spirifer Pellensis

Spiriferina transversa
Composita trinuclea
Cliothyridina sublamellosa
Myalina elongata
Griffithides sp.

Sinks Grove Limestone—Lots 178 and 179 (Type Locality).

Triplophyllum Pellense
Lithostrotion? sp.
Crinoid indet.
Stenopora sp.
Batostomella sp.
Fenestella sp.
Productus parvus
Spirifer Pellensis
Cliothyridina sublamellosa
Platyceras sp.

[These two collections (178 and 179) are so poor that a better one may be added, listed separately. This is Lot 112].

Triplophyllum sp.
Orthotetes Kaskaskiensis
Productus ovatus
Productus inflatus
Productus parvus
Pustula Genevievensis
Moorefieldella Eurekensis var.
Dielasma sp.
Girtyella Indianensis
Spirifer Pellensis var.
Spiriferina transversa
Composita trinuclea
Composita Lewisensis
Cliothyridina sublamellosa.

Hillsdale Limestone—Lot 144 (Type Locality).

Syringopora Monroensis
Triplophyllum Pellense
Lithostrotion proliferum?
Lithostrotion basaltiforme?
Fistulipora sp.
Batostomella sp.
Stenopora sp.
Hemitrypa n. sp.
Fenestella tenax
Fenestella sev. sp.
Polypora 2 sp.
Dichotrypa intermedia
Crania aff. levis
Orthotetes Kaskaskiensis
Productus ovatus
Productus aff. inflatus
Productus scitulus?
Pustula n. sp.

Diaphragmus elegans var.
Spirifer Pellensis
Spirifer bifurcatus
Spiriferina aff. Salemensis
Composita trinuclea
Cliothyridina sublamellosa
Allerisma? sp.

MACCRADY SERIES—MISSISSIPPIAN.

Lot 214.

(In upper portion of the outcrops of Monroe County but probably near middle of typical Maccrady of Virginia. No subdivisions of series yet made.—D. B. R.)

Stenopora ramosa?
Stenopora ramosa var. Fayettevillensis?
Batostomella sp.
Fenestella tenax
Fenestella sp.
Polypora sp.
Orthotetes Kaskaskiensis
Productus ovatus
Camarotechia Purduei var. agrestis?
Cliothyridina sublamellosa?
Aviculipecten aff. Monroensis
Griffithides sp.
Hollina cf. granifera.

POCONO SERIES—MISSISSIPPIAN.

Broad Ford Sandstone—Lot 297.

(In listing the collection numbered 297, I have rather stretched good practice in order to give a better idea of the fauna. The fossils are few and ill preserved, and I have listed types represented by one or two obscure impressions that might better, perhaps, have been thrown away. This is the reason why so many forms in this list are cited by the genus alone).

Cladochonus aff. Beecheri
Fenestella sp.
Chonetes sp.
Chonetina? sp.
Rhynchopora aff. Beecheri?
Athyris? sp.
Pleurotomaria sp.
Euphemus? sp.
Platycerass aff. P. Crytolites
Platyceras sp.
Proetus sp.

Sunbury Shale—Lot 296.

[Although the two species cited in Lot 296 appear to be the same as two species that occur in the Sunbury Shale (and I have compared the specimens in each case with the specimens from the original localities in the Sunbury Shale) you should not, I hardly need advise you, attach much importance to this fact in the way of correlation. Shells scarcely if at all distinguishable from these occur at other horizons, in fact in many black shales irrespective of geologic age.—G. H. G.]

(As previously stated on pages 525-529 of this Report the correlation of the Sunbury is made on very good stratigraphic grounds while at the same time the fauna is regarded as good corroborative evidence. In justice to Dr. Girty's viewpoint any mistake in this matter rests wholly on the writer.—D. B. R.)

Lingula melie
Lingulidiscina Herzeri.

FAUNAS OF THE DEVONIAN, SILURIAN, AND ORDOVICIAN PERIODS.

By William F. Prouty.

BRIEF FAUNAL DISCUSSION.

The following discussion is based on the study of certain portions of the Paleozoic rocks occurring in Mercer, Monroe, and Summers Counties, West Virginia.

Collections were made during summer field work in company with Mr. David B. Reger of the West Virginia Geological Survey. These collections were later studied in the laboratory at the University of North Carolina. The only collections studied in detail were from the Devonian or older rocks. The following geological divisions were represented in these collections: Chemung, Hamilton, Marcellus, Oriskany, Clinton, Medina, Martinsburg, Chickamauga, and Beekmantown.

The most numerous collections were as follows: from the Chemung, 15 collections; Martinsburg, 46 collections; Beekmantown, 15 collections; Chickamauga, 17 collections; Clinton, 7 collections.

The formal discussion will necessarily be confined to the formations from which collections were made in some detail.

Martinsburg Series.

More collections were taken from this formation than from any other and of these a larger majority came from the upper portion. This is due to the better exposure of the upper part of the Martinsburg in most sections, rather than the middle or lower portion. The only complete section of the middle and lower part of the Martinsburg from which fossils were collected is the one exposed along the highway on the north side of Peters Mountain to the south of Gap Mills (See Hanging Rock Section, pages 234-237) in Monroe County. A number of collections from different parts of the Martinsburg were collected along the main highway over East River Mountain southeast from Bluefield. The section on the east side of New River near the Narrows (See Rich Creek Section, pages 210-211) has very good exposures in the upper portion and the lower portion of the Martinsburg. This section also yielded some very good collections.

Table I gives a list of the different fossils studied from the Martinsburg and their occurrence. Each fossil is listed under a lot number. A description of these lots is given elsewhere in this volume, under "List of Fossil Localities."

The faunal study shows that there are three well-marked divisions in the Martinsburg; the **Maysville**, the **Eden**, and the **Trenton**. In the **Maysville** both the **Orthorhynchula linneyi Zone** and the overlying **Lingula nicklesi Zone** are well represented. The chief fossils from the Maysville are: **Orthorhynchula linneyi, Lingula nicklesi, Modiolopsis modiolaris, Modiolopsis** sp., **Clidophorus** sp., **Byssonychia radiata.**

The **Eden** shales and sandstones have an abundant and conspicuous brachipod fauna: **Rafinesquina alternata, Rafinesquina alternata var. fracta, Plectambonites sericeus, Dalmanella multisecta, Dalmanella testudinaria, Zygospira modesta, Zygospira recurvirostris, Zygospira modesta var. cincinnatiensis, Pholidops cincinnatiensis.** The other chief forms

present in the Eden are: **Calymene callicephala, Isotelus** sp., **Hormotoma** sp., **Callopora sigillaroides,** and a few other forms.

The **Trenton** portion of the Martinsburg is, perhaps, less well represented by characteristic fauna than the upper two divisions, but this portion has yielded: **Isotelus gigas, Pterygometopus callicephalus, Ceraurus pleurexanthemus, Cryptolithus tessellatus, Dalmanella testudinaria, Sinuites cancellatus, Prasopora simulatrix, Spyroceras bilineatum, Diplograptus vespertinus, Rafinesquina alternata, Plectambonites sericeus, Dalmanella multisecta.**

The Hanging Rock Section, on the west slope of Peters Mountain, has the best exposure of the lower portion of the Martinsburg studied anywhere in the three counties. Here collections 71-98, inclusive, were made. These collections range from the base to an elevation of 340 feet above the base. The upper limit of the **Prasopora simultarix** (the assumed top of the Trenton) is here about 240 feet above the base. The **Sinuites cancellatus Zone** occurs about 90 feet above the Martinsburg-Moccasin Limestone contact. The upper portion of the Eden is largely concealed in this section, but the two faunal zones of the Maysville (the **Orthorhynchula linneyi,** and the **Lingula nicklesi Zones)** are well represented.

In the section northeast of the Narrows the Moccasin Limestone and the **Sinuites Zone** of the Martinsburg are separated by approximately the same thickness of strata but at the Narrows the intervening beds are much more carbonaceous and sandy and less fossiliferous. In this section the Martinsburg is as a whole more limy than at any other exposure studied in the three counties and as a consequence more highly fossiliferous, although it is more difficult to collect good fossils from the limestones than from the shale. In this (Rich Creek) section the contact between the Juniata (Red Medina) and the **Lingula nicklesi Zone** of the Martinsburg is well exposed. The unconformity is marked by a 1"—2" bed of chert pebbles.

The Lingula of the **L.-nicklesi Zone** is not restricted to the upper portion of the Maysville but extends into the **Orthorhynchula linneyi Zone.** The **Orthorhynchula linneyi** on the

other hand is restricted and does not occur to the top of the Maysville.

The Trenton portion of the Martinsburg is not as well defined faunally in the East River Mountain section near Bluefield as it is in the other two localities just discussed to the northeast.

Moccasin and Chickamauga Limestones.

A number of sections in Mercer, Monroe, and Summers Counties expose a considerable thickness of limestone below the Martinsburg shales and limestones. These sections in most places show the non-fossiliferous, impure, red "Moccasin" Limestone immediately beneath the Martinsburg, followed by the fossiliferous and less impure limestones of "Chickamauga" age. These in turn are followed locally by a more or less cherty limestone and dolomite of considerable thickness, which has an abundant fauna in a few horizons. These lower rocks fall largely under the Canadian and Ozarkian of Dr. Ulrich. A number of collections have been made from these limestones and dolomites below the Moccasin. Fossils are most abundant in the upper, or Chickamauga, portion of the limestones, but here good collecting can not be had except in localities where the shells are slightly more siliceous than the rest of the limestones and where weathering has been active for a long time. Two divisions of the Chickamauga have been made as a result of the fossil study; the Chambersburg and the Stones River. Beneath the Stones River Limestone a number of collections have been taken from the Beekmantown but the few exposures of older Ozarkian and Cambrian have yielded no diagnostic fossils.

Table II shows a list of Chickamauga fossils collected in the various localities. Most of these are from the Black River portion of the Chambersburg Limestone, while the remainder are from the Stones River portion of the Chazyan. Perhaps the best exposure of the zone between the Chambersburg and the Chazyan is at the Kimballton Lime Quarries near Pearisburg. The Beekmantown Limestone and dolomite is well represented in a number of localities, the most common

fossil being **Ophileta complanata, O. levata, Hormotoma** sp., **Cyrtoceras** sp., and **Ooceras** sp.

Clinton Series.

The Clinton fossils studied are largely characteristic of the middle to upper portion of the formation. No characteristically Rochester forms were collected. **Table III** shows the distribution of the few forms studied.

Devonian Period.

Collections from the Devonian were largely made in the upper sandstone and shale portions. The typical Parkhead Sandstone fossils occur here as does also the typical **Spirifer disjunctus** fauna of the higher portion of the upper Devonian. A list of the fossils occurring in the various sections of the upper Devonian is given in **Table IV.**

Table I: Martinsburg Fossils.

| Species | Lot Numbers | | |

Table II: Chickamauga Fossils.

Species	Lot Numbers																	
	12	19	20	21	24	44	45	46	47	48	53	54	55	58	60	62	70	105
Rafinesquina cf. minnesotensis				x														
Christiana Trentonensis							x											
Orthothetes sp		x	x				x		x		x						x	
Solenopora compacta														x				
Ramose bryozoa		x	x	x		x										x		
Nidulites cf. pyriformis											x							
Crinoid stem								x			x							
Omospira alexandria	x																	
Lophospira perangulata										x								
Liospira cf. vitruvia	x									x								
Maclurites cf. bigsbyi										x								
Maclurites sp			x															
Operculum of Maclurites											x							
Raphistoma cf. stamineum												x						
Strophylus? sp												x						
Small gastropod sp																x		
Cuneamya sp													x					
Orthoceras sp				x			x											
Bumastus sp								x			x				x			
Isotelus sp		x					x											
Trilobite sp		x							x									
Leperditia cf. fabulites									x									
Bythocypris cf. cylindrica													x					
Ostracod, large and smooth				x			x	x			x							
	12	19	20	21	24	44	45	46	47	48	53	54	55	58	60	62	70	105

x—present
x—abundant

Table III: Clinton Fossils.

Species	Lot Numbers						
	33	34	35	36	37	67	136
Chonetes novascoticus			x		x		
Coelospira hemispherica		x	x	x			
Coelospira planoconvexa		x					
Camarotoechia neglecta				x	x		
Dalmanella sp				x			
Calymene clintoni		x		x	x		x
Calymene cresapensis					x		
Calymene cf. macropleura					x		
Calymene sp				x		x	x
Orthoceras sp						x	x
Tentaculites minutus		x		x		x	
Zygobolba aff. carinifera						x	
Zygobolba cf. decora				x			
Zygobolba sp			x				
Zygobolbina emacerata				x	x		
Crinoid stem		x	x	x			
Buthotrephis graeilis var					x		
	33	34	35	36	37	67	136

x—present.

Table IV: Upper Devonian Fossils.

Species	Lot Numbers														
	13	14	15	16	17	18	40	41	42	43	131	137	141	142	143
Camarotoechia sappho	x														
Camarotoechia cf. contracta (b)			x	x	x	x									
Camarotoechia congregata var. parkheadensis							x								
Camarotoechia eximia												x			
Spirifer disjunctus	x														
Spirifer cf. marcyi var. superstes									x						
Spirifer mucronatus var									x						
Spathella cf. typica										x					
Lingula melie (a)	x														
Athyris sp. (b)			x												
Productus cf. semircticulatus (b)			x												
Productella sp								x		x					
Chonetes sp								x	x	x					
Rhipidomella sp														x	
Aviculopecten aff. duplicatus														x	
Cf. Cypricardinia elegans												x			x
Grammysia subarcuata												x			
Leiopteria cf. bigsbyi							x								
Pelecypod sp				x	x										
Bellerophon cf. clarki									x						
Bellerophon sp								x		x					x
Hyolithes aclis								x							
Douvillina cayuta											x				
Trilobite sp				x											
Ostracod sp														x	x
Crinoid sp				x	x		x							x	
Plant sp							x								
	13	14	15	16	17	18	40	41	42	43	131	137	141	142	143

x—present
x—abundant

a. Lot 13 was a mixed collection from the Chemung Series of the Devonian and partly from the Pocono Series of the Mississippian. **Lingula melie** was found in the Sunbury Shale of the Pocono. See discussion page 526 (D. B. R.).

b. Lot 15 has been previously assigned to the Mississippian by Dr. Prouty and appears to have been inadvertently included in this list. See Lurich. Section, page 205 (D. B. R.).

APPENDIX.

LEVELS ABOVE MEAN TIDE.

RAILROAD LEVELS.

MAIN LINE, CHESAPEAKE & OHIO RAILWAY,

(Elevations on top of rail.)

Miles from Fortress Monroe	Stations.	State	County.	Elevation Feet.
308.0	Tuckahoe	W. Va.	Greenbrier	2048
311.9	White Sulphur	W. Va.	Greenbrier	1930
314.9	Dickson	W. Va.	Greenbrier	1860
315.5	Hart's Run	W. Va.	Greenbrier	....
317.3	Caldwell	W. Va.	Greenbrier	....
319.8	Whitcomb	W. Va.	Greenbrier	1705
322.8	Ronceverte	W. Va.	Greenbrier	1670
326.5	Rockland	W. Va.	Greenbrier	1663
329.0	Fort Spring	W. Va.	Greenbrier	1636
330.3	Snow Flake	W. Va.	Greenbrier	....
330.8	Frazier	W. Va.	Greenbrier	....
332.6	Halfway	W. Va.	Greenbrier	....
335.8	Alderson	W. Va.	Monroe	1556
337.7	Mohler	W. Va.	Monroe	....
339.4	Wolf Creek	W Va.	Monroe	....
341.5	Riffe	W. Va.	Monroe	....
343.3	Pence Springs	W. Va.	Monroe	1540
345.3	Lowell	W. Va.	Summers	....
347.2	Talcott	W. Va.	Summers	....
347.8	Big Bend	W. Va.	Summers	1530
349.5	Hilldale	W. Va.	Summers	....
352.6	Wiggins	W. Va.	Summers	1410
357.0	Hinton	W. Va.	Summers	1378
360.0	Barksdale	W. Va.	Summers	....
362.0	Brooks	W. Va.	Summers	1345
366.1	Sandstone	W. Va.	Summers	1299
369.6	Meadow Creek	W. Va.	Summers	1276
374.3	Glade	W. Va.	Fayette	1245
378.7	Quinnimont	W. Va.	Fayette	1205
379.9	Prince	W. Va.	Fayette	1203
380.8	XN Cabin	W. Va.	Fayette	1203
383.1	McKendree	W. Va.	Fayette	1135
385.0	Thayer	W. Va.	Fayette	1116
387.0	Alaska	W. Va.	Fayette	....
387.8	Claremont	W. Va.	Fayette	....
389.1	Stone Cliff	W. Va.	Fayette	1077
391.8	Thurmond	W. Va.	Fayette	1070
392.2	Dimmock	W. Va.	Fayette	....
392.4	Rush Run	W. Va.	Fayette	....
393.2	Beury	W. Va.	Fayette	....

MAIN LINE, CHESAPEAKE & OHIO RAILWAY (Continued).

Miles from Fortress Monroe.	Stations.	State.	County.	Elevation. Feet.
394.0	Central	W. Va.	Fayette	....
394.5	Fire Creek	W. Va.	Fayette	1038
396.4	East Sewell	W. Va.	Fayette	1012
397.6	Sewell	W. Va.	Fayette	....
399.3	Caperton	W. Va.	Fayette	....
400.4	Keeney's Creek	W. Va.	Fayette	....
401.6	Nuttall	W. Va.	Fayette	954
404.3	Fayette	W. Va.	Fayette	909
404.9	Newlyn	W. Va.	Fayette	....
405.5	Michigan	W. Va.	Fayette	....
405.6	Elmo	W. Va.	Fayette	....
406.8	Sunnyside	W. Va.	Fayette	....
407.6	Gaymont	W. Va.	Fayette	....
408.6	Hawk's Nest	W. Va.	Fayette	837
408.9	McDougall	W. Va.	Fayette	836
410.8	Cotton Hill	W. Va.	Fayette	796
415.2	Gauley	W. Va.	Fayette	723
415.9	Old Gauley	W. Va.	Fayette	....
417.9	Kanawha Falls	W. Va.	Fayette	677

SEWELL VALLEY RAILROAD,
(Elevations on top of rail.)

Miles from Meadow Creek.	Stations.	State.	County.	Elevation. Feet.
0.0	Meadow Creek	W. Va.	Summers	1273
2.6	Beurytown Mine	W. Va.	Summers	....
2.6	Beurytown	W. Va.	Summers	1556
4.6	Claypool Mine	W. Va.	Summers	....
4.9	Claypool	W. Va.	Summers	1868
5.5	Tina	W. Va.	Summers	....
6.0	Naylor Switchback	W. Va.	Summers	....
6.5	Dilly Siding	W. Va.	Summers	....
7.3	Camp Seven Switchback	W. Va	Summers	2325
7.3	Meadow Creek Switchback	W. Va.	Summers	....
8.5	Meadow Bridge	W. Va.	Fayette	2420
8.6	Meadow Bridge Mine.	W. Va.	Fayette	....
8.7	Hawley	W. Va.	Fayette	2435
8.8	Hawley Mine Siding	W. Va.	Fayette	....
10.6	Arthurs	W. Va.	Fayette	2615
11.7	Teays Siding	W. Va.	Fayette	....
11.8	Springdale	W. Va.	Fayette	2770
11.9	Lowerys Siding	W. Va.	Fayette	....
395.2	Pennbrook	W. Va.	Fayette	....

SEWELL VALLEY RAILROAD (Continued).
(Elevation on top of rail.)

Miles from Meadow Creek	Stations.	State	County.	Elevation Feet.
13.9	Youngs	W. Va.	Fayette	2675
16.2	Bellwood	W. Va.	Fayette	2505
16.3	Wilt Siding	W. Va.	Fayette	....
16.4	Griffith Siding	W. Va.	Fayette	....
16.5	Sevy	W. Va.	Fayette	2465
17.6	Sims	W. Va.	Greenbrier	2419
19.7	Rainelle	W. Va.	Greenbrier	2419
20.1	Rainelle Junction	W. Va.	Greenbrier	2395
21.9	Dwyer	W. Va.	Fayette	2395
22.0	Green Siding	W. Va.	Fayette	....
24.7	Surbaugh	W. Va.	Fayette	2368
27.6	Honeydew	W. Va.	Fayette	2325
28.0	Cruikshanks Farm	W. Va.	Fayette	....
28.7	Crusher Siding	W. Va.	Fayette	....
30.6	Burdette Creek	W. Va.	Greenbrier	2268
....	Dry Creek	W. Va.	Greenbrier	1976
37.0	Russellville	W. Va.	Greenbrier	1904
40.0	Nallen	W. Va.	Fayette	1892

The above levels on the Sewell Valley Railroad were sent the Survey by T. W. Raine, President, under date of September 30, 1918.

MAIN LINE, NORFOLK AND WESTERN RAILWAY.
(Elevations on subgrade, 17 inches below base of rail.)

Miles from Norfolk.	Stations.	State.	County.	Elevation. Feet.
342.41	Wills	W. Va.	Mercer	1614
346.96	Oakvale	W. Va.	Mercer	1703
351.08	Hardy	W. Va.	Mercer	1863
352.73	Ingleside	W. Va.	Mercer	1842
353.89	East River	W. Va.	Mercer	1995
356.95	Tulip	W. Va.	Mercer	2136
358.73	Ada	W. Va.	Mercer	2213
363.08	Bluefield	W. Va.	Mercer	2556
372.26	Abbs Valley	W. Va.	Mercer	2291
372.92	Dayton	W. Va.	Mercer	2287
373.84	Bluestone Junction	W. Va.	Mercer	2281
374.94	Wood	W Va.	Mercer	2272
375.29	Cooper	W. Va.	Mercer	2266
376.68	Ruth	W. Va.	Mercer	2388

MAIN LINE, NORFOLK AND WESTERN RAILWAY. (Continued)

(Elevation on subgrade, 17 inches below base of rail)

Miles from Norfolk	Stations.	State	County.	Elevation Feet.
376.80	East End Tunnel....	W. Va.	Mercer	2384
377.42	Coaldale	W. Va.	Mercer	2336
379.53	Maybeury	W. Va.	McDowell	2147
380.39	Switchback	W. Va.	McDowell	2070
381.40	Ennis	W. Va.	McDowell	1995
382.94	Elkhorn	W. Va.	McDowell	1882
384.36	Powhatan	W. Va.	McDowell	1796
385.00	Kyle	W. Va.	McDowell	1760
385.99	North Fork Junction.	W. Va.	McDowell	1700
387.4	Keystone	W. Va.	McDowell	1635
388.35	Eckman	W. Va	McDowell	1588
389.30	Landgraff	W. Va.	McDowell	1569
390.84	Vivian	W. Va.	McDowell	1515
391.54	Vivian Yard.....	W. Va.	McDowell	1494
392.40	Norwood	W. Va.	McDowell	1475
396.44	Huger	W. Va.	McDowell	1340
399.2	Welch	W. Va.	McDowell	1297

BLUESTONE BRANCH—N. AND W. RAILWAY.

(Elevations on subgrade, 17 inches below base of rail.)

Miles from Bluestone Junction.	Stations.	State.	County.	Elevation. Feet.
0.00	Bluestone Junction..	W. Va.	Mercer	2281
1.50	Pocahontas	Virginia	Tazewell	2315

COOPER AND GOODWILL BRANCH—N. AND W. RAILWAY.

(Elevations on subgrade, 17 inches below base of rail.)

Miles from Cooper.	Stations.	State.	County.	Elevation. Feet.
0.00	Cooper	W. Va.	Mercer	2266
1.14	Bramwell	W. Va.	Mercer	2247
1.80	Simmons Creek Junction	W. Va.	Mercer	2242
5.48	Johnson's	W. Va.	Mercer	2216
5.93	Flipping Creek Junction	W. Va.	Mercer	2210
6.35	Duhring	W. Va.	Mercer	2215
7.91	Goodwill	W. Va.	Mercer	2262

CRANE CREEK BRANCH—N. & W. RAILWAY.
(Elevations on subgrade, 17 inches below base of rail.)

Miles from Norfolk.	M.P.	Stations.	State.	County.	Elevation. Feet.
381.22	0.0	Flipping Creek Junction.	W. Va.	Mercer ..	2217
.....	2.0	Montcalm Junction, Widemouth Branch...	W. Va.	Mercer ..	2210
.....	5.3	Moroa	W. Va.	Mercer ..	2335

WIDEMOUTH BRANCH—N. & W. RAILWAY.
(Elevations on subgrade, 17 inches below base of rail.)

Miles from Norfolk.	M.P.	Stations.	State.	County.	Elevation. Feet.
382.32	0.0	Junction with Crane Creek Branch.....	W. Va.	Mercer ..	2210
.....	...	Montcalm	W. Va.	Mercer ..	....
.....	2.76	Rock	W. Va.	Mercer ..	2198
.....	8.35	Giatto	W. Va.	Mercer ..	2374
.....	12.33	Clark's Gap.....	W. Va.	Mercer ..	2520

MAIN LINE, VIRGINIAN RAILWAY.
(Elevations on top of rail.)

Miles from Sewall's Point.	Stations.	State.	County.	Elevation. Feet.
322.8	Pearisburg	Virginia	Giles	1574.1
328.4	Rich Creek	Virginia	Giles	1532.9
337.1	Kelleysville	W. Va.	Mercer	1673.3
340.6	Stengel	W. Va.	Mercer	1905.3
344.1	Ingleside	W. Va.	Mercer	2183.8
350.7	Princeton	W. Va	Mercer	2395.0
351.5	Gardner Junction...	W. Va.	Mercer	2387.2
354.6	Kegley	W. Va.	Mercer	2335.3
358.2	King	W. Va.	Mercer	2261.6
361.1	Rock	W. Va.	Mercer	2231.0
366.1	Matoaka	W. Va.	Mercer	2389.2
367.2	Giatto	W. Va.	Mercer	2405.8
370.9	Clarks Gap.....	W. Va.	Mercer & Wyoming.	2523.5
373.9	Micajah	W. Va.	Wyoming	2273.6
377.9	Herdon	W. Va.	Wyoming	1890.7
382.3	Taft	W. Va.	Wyoming	1495.7
385.7	Elmore	W. Va.	Wyoming	1399.3
387.3	Mullens	W. Va.	Wyoming	1425.9

UNITED STATES GEOLOGICAL SURVEY LEVELS.

The various topographic quadrangles which make up the areas of Mercer, Monroe, and Summers Counties have been covered with a network of primary spirit-levels run by the Topographic Branch of the United States Geological Survey, with financial cooperation from the West Virginia Geological Survey. In addition to these a few precise lines differing mainly in the manner in which they are checked for errors, as hereinafter quoted, have also been run. Some of these levels have already been published in various bulletins of the United States Geological Survey but all of the lines which lie wholly or partly in the three counties under study are now published in full in the following pages, as supplied by Dr. George Otis Smith, Director, United States Geological Survey.

By way of explanation the following descriptive remarks are quoted from Bulletin No. 632 of the United States Geological Survey, pages 5-7; 1916, the same being followed by the detailed levels:

"**Classification.**—The elevations are classified as precise or primary, according to the methods employed in their determination. The former are determined by lines of levels run either in both forward and backward directions or by simultaneous double-rodded lines, a high-grade instrument being used and special precautions being taken in observations and reduction to correct errors and make the line continuously good throughout. The latter or primary levels are determined with the Y level, precautions being taken against only the principal errors and the levels being run mostly in circuits of single lines. The allowable limit of error observed in the precise work already done by the Geological Survey in this State is represented in feet by 0.2 times the square root of D and that for the primary work by 0.05 times the square root of D, in which D is the length of circuit in miles.

"**Bench Marks.**—The standard bench marks are of two forms. The first form is a circular bronze or aluminum tablet 3½ inches in diameter and ¼ inch thick, having a 3-inch stem, which is cemented in a drill hole in solid rock in the wall of some public building, a bridge abutment, or other substantial masonry structure. The second form used where masonry or rock is not available, consists of a hollow wrought-iron post 3½ inches in outer diameter and 4 feet in length. The bottom is spread out to a width of 10 inches in order to give a firm bearing on the earth. A bronze or aluminum cap is rivited upon the top of the post which is set about 3 feet in the ground. A third style of bench mark, with abbreviated lettering is used for unimportant points. This consists of a special copper nail 1½ inches in length driven through a copper washer ⅞ inch in diameter. The

tablets as well as the caps on the iron posts are appropriately lettered, and cooperation by States is indicated by the addition of the State name.

"The numbers stamped on the bench marks described in the following pages represent the elevations to the nearest foot as determined by the levelman. These numbers are stamped with 3-16-inch steel dies on the tablets or post caps, to the left of the word 'Feet'. The office adjustment of the notes and the reduction to mean sea-level datum may so change some of the figures that the original markings are 1 or 2 feet in error. It is assumed that engineers and others who have occasion to use the bench-mark elevations will apply to the Director of the United States Geological Survey, at Washington, D. C., for the adjusted values, and will use the markings as identification numbers only.

"Datum.—All elevations determined by the United States Geological Survey and the United States Coast and Geodetic Survey are referred to mean sea-level, which is the level that the sea would assume if the influence of winds and tides were eliminiated. This level is not the elevation determined from the mean of the highest and the lowest tides, nor is it the half sum of the mean of all the high tides and the mean of all the low tides, which is called the half-tide level. **Mean sea-level is the average height of the water, all stages of the tide being considered.** It is determined from observations made by means of tidal gages placed at stations where local conditions, such as long narrow bays, rivers, and like features, will not affect the height of the water. To obtain even approximately correct results these observations must extend over at least one lunar month, and if accuracy is desired they must extend over several years. At ocean stations the half-tide level and the mean sea-level usually differ but little. It is assumed that there is no difference between the mean sea-levels determined from observations in the Atlantic Ocean, the Gulf of Mexico, and the Pacific Ocean.

"The connection with tidal stations for bench-marks in certain areas that lie at some distance from the seacoast is still uncertain, and this fact is indicated by the addition of a letter or word to the right of the word 'Datum' on tablets or posts. For such areas corrections for published results will be made from time to time as the precise-level lines of the United States Geological Survey, the United States Coast and Geodetic Survey, or other Government organizations are extended."

ALDERSON QUADRANGLE: GREENBRIER, MONROE, AND SUMMERS COUNTIES.

(Latitude 37°30′-37°45′; Longitude 80°30′-80°45′.)

Primary leveling by R. G. Stevenson in 1920:

From Fort Spring along highways south to Union, thence northwest to Alderson.

	Feet.
Fort Spring, directly opposite station, at margin of highways, in railroad retaining wall; aluminum tablet stamped "1,622" (Bulletin 632, p. 10).....	1,621.565

	Feet.
Fort Spring, 1.3 miles south of, dwelling house 20 feet south of, 150 feet north of second-class road running west, on west side of road, in small limestone rock; chiseled square, "T. B. M. 2,024.1" marked.	2,024.19
Fort Spring, 2.0 miles south of, 30 feet southeast of mail-box, 500 feet east of dwelling house, on east side of road, in small limestone rock; chiseled square, "T. B M. 2,073.0" marked.....	2,073.05
Fort Spring, 2.6 miles south of, 400 feet west of dwelling house, 100 feet east of gate to private road, 8 feet south of rail fence, on north side of road, in limestone boulder; bronze tablet stamped "W. Va. 2,143"	2,143.395
Fort Spring, 3.4 miles south of, on east side of road, in concrete post (Greenbrier-Monroe County line); chiseled square, marked "T. B. M. 2,148.2".....	2,148.30
Rocky Point (Sinks Grove P. O.), 1.5 miles north of, 50 feet east of dwelling house, 2 feet south of T road running east to Ronceverte, 40 feet east of cherry tree, on east side of road, in large limestone rock; chiseled square, marked "T. B. M. 2,240.4".....	2,240.48
Rocky Point (Sinks Grove P. O.), 170 feet south of, 22 feet west of boardwalk, 12 feet west of main road, 10 feet north of large walnut tree, 30 feet east of B. E. Humphreys' residence; bronze tablet stamped "W. Va. 2,179".....	2,178.564
Rocky Point (Sinks Grove P. O.), 0.8 mile southeast of, 80 feet southwest of intersection of crossroads, 30 feet west of large maple tree, on west side of road, in small limestone rock; chiseled square, "T. B. M. 2,290.5" marked.....	2,290.57
Rocky Point (Sinks Grove P. O.), 1.4 miles south of, 250 feet north of dwelling house, 10 feet southeast of second-class T road running west, 150 feet northeast of small unpainted barn, on east side of road, in small limestone rock; chisled square, marked "T. B. M. 2,231.6".....	2,231.76
Rocky Point (Sinks Grove P. O.), 2.5 miles south of, 30 feet east of cherry tree, 30 feet north of gate to private road, 1,200 feet west of residence of Reverend Mr. Hudson, on east side of road, in small flat limestone rock; bronze tablet stamped "W. Va. 2,305".....	2,304.644
Union, 1.9 miles north of, 700 feet south of main road forks, on west side of road, in root of large white oak tree 36 inches in diameter; copper nail and washer, marked "T. B. M. 2,184.0".....	2,184.03

	Feet.
Union, 0.7 mile northeast of, 20 feet south of small run crossing road, 40 feet southeast of gate to private road, 250 feet north of dwelling house, on east side of road, in small flat limestone rock; chiseled square, marked "T. B. M. 2,016.9"	2,017.02
Union, 0.9 mile northwest of, 10 feet southwest of second-class road running northeast, 30 feet north of rail fence, on south side of road, in large flat limestone rock; chiseled square, painted "T. B. M. 2,100.2"	2,100.28
Union, 1.9 miles northwest of, 500 feet southeast of dwelling house, 15 feet north of main road, on north side of road, in large flat limestone rock; chiseled square, painted "T. B. M. 2,429.1"	2,429.26
Union, 3.4 miles northwest of, 10 feet north of Mount Prospect Baptist Church, 50 feet south of T road intersection, 400 feet southwest of unpainted barn, on south side of main road running east and west, in large flat sandstone rock; bronze tablet stamped "W. Va. 2,899"	2,898.730
Union, 3.7 miles northwest of, 90 feet south of T road running west, 20 feet west of rail fence, on west side of road, in small maple tree 1.5 feet in diameter; copper nail and washer, "T. B. M. 2,905.0" painted	2,905.27
Union, 5.0 miles northwest of, 600 feet northeast of dwelling house, 5 feet west of rail fence, 30 feet north of private lot gate, on east side of road, in small limestone rock; chiseled square, painted "T. B. M. 2,668.7"	2,668.93
Union, 6.0 miles northwest of, 75 feet north of bend in road, 10 feet west of rail fence, on east side of road, in large limestone rock; chiseled square, marked "T. B. M. 2,296.4"	2,296.50
Union, 7.9 miles northwest of, 7 miles west of Rocky Point, 1 mile southeast of Wolf Creek store, 50 feet west of T road intersection, 40 feet south of rail fence, on south side of road running east and west, in large limestone rock; bronze tablet stamped "W. Va. 1,700"	1,699.938
Wolf Creek store, 330 feet west of, 40 feet east of intersection of T road running west, 40 feet east of sign-board marked "Sinks Grove 6 miles", on east side of road, in small limestone rock; chiseled square, marked "T. B. M. 1,586.4"	1,586.47
Wolf Creek store, 1.3 miles northwest of, 100 feet east of Broad Run, 40 feet west of rail fence, 40 feet northeast of small walnut tree, on east side of road, in small limestone rock; chiseled square, painted "T. B. M. 1,572.3"	1,572.33

Feet.

Wolf Creek store, 2.1 miles northwest of, 80 feet east of Wolf Creek, 40 feet west of main road, 15 feet east of 10-inch maple tree, 800 feet northwest of residence of Mr. Leach, 30 feet west of wire fence, in large flat limestone rock; bronze tablet stamped "W. Va. 1,540 1920"..... 1,540.356

Wolf Creek store, 3.1 miles northwest of, 300 feet south of dwelling house, 10 feet east of private gate to lot, 250 feet east of large unpainted barn, 50 feet west of private road running east, on west side of road, in small limestone rock; chiseled square, painted "T. B. M. 1,550.2"..... 1,550.18

Wolf Creek station, 120 feet east of, 4 feet north of track in west end of platform; copper nail and washer, painted "T. M. B. 1,535.6"..... 1,535.621

Alderson, 2.52 miles west of, 0.38 mile south of mile-post "Cin. 327", west of track, in top of railroad culvert; aluminum tablet stamped "1,534"..... 1,533.252

Primary leveling by R. G. Stevenson in 1920 and E. E. Harris in 1921:

From Union along highways south to Salt Sulphur Springs, thence southeast to Willow Bend.

Union, 160 feet east of post-office, in front of Monroe County Court-house; bronze tablet stamped "W. Va. 2,070" 2,070.086

Witness bench mark, 23.5 feet S. 65° W. of above tablet; chiseled square in southwest corner of walk at front entrance to court-house..... 2,069.49

Union, 0.7 mile southwest of, 100 feet south of large walnut tree, 500 feet northeast of dwelling house, 10 feet west of wire fence, on east side of road, in large limestone boulder; chiseled square..... 1,972.40

Salt Sulphur Springs, 0.9 mile northeast of, 20 feet north of private road running east, 75 feet southwest of cattle scales, 10 feet north of mail-box, on top of main beam to culvert; copper nail and washer. 1,895.90

Salt Sulphur Springs, in north side of post-office, on east end, 1 foot above surface of ground, in side of stone foundation; bronze tablet stamped "W. Va. 1,802" 1,802.310

Witness bench mark, 46.6 feet S. 80° E. of above tablet; in north end of culvert under main road; copper nail and washer..... 1,797.68

Salt Sulphur Springs, 0.9 mile south of, 100 feet north of T road intersection, 200 feet west of Indian Creek, on west side of road, in small limestone rock; chiseled square..... 1,798.59

	Feet.
Willow Bend, 1.1 miles northwest of, 50 feet south of run, 150 feet east of right angle in road, 250 feet southeast of farm house, 20 feet south of wire fence, on south side of road, in root of 15-inch sycamore tree; copper nail and washer	1,807.09
Willow Bend, 0.3 mile north of, at inntersection of T road, in small limestone rock; chiseled square	1,905.58
Willow Bend, in southwest corner of E. O. Rowan's store, in large boulder; bronze tablet stamped "W. Va. 1920 1,914"	1,913.830
Witness bench mark, 20 feet S. 65° W. of tablet, on top of large rock boulder; chiseled square	1,911.57

Primary leveling by R. G. Stevenson in 1920:

From Salt Sulphur Springs southwest along highways to Greenville.

Lillydale, 2.1 miles east of, 250 feet east of dwelling house, 150 feet south of right angle in road, 10 feet east of wire fence, on west side of road, in large flat limestone rock; chiseled square, "T, B. M. 1,910.0" painted	1,910.17
Lillydale, 0.9 mile east of, 120 feet west of unpainted barn, 400 feet northwest of dwelling house, 100 feet east of large walnut tree, on north side of road, in small limestone rock; chiseled square, painted "T. B. M. 1,885.6" (erroneously)	1,855.78
Lillydale, intersection of crossroads, 200 feet north of, 50 feet east of main road to Greenville, 400 feet north of dwelling house, 450 feet west of Mount Heading Church, on east side of road, in limestone foundation of store; bronze tablet stamped "W. Va. 1,793 1920"	1,792.962
Lillydale, 0.7 mile northwest of, 350 feet east of dwelling house, 30 feet southeast of small cherry tree, 20 feet north of wire fence, on north side of road, in small limestone rock; chiseled square, painted "T. B. M. 1,913.1"	1,913.27
Greenville, 3.4 miles east of, 10 feet northeast of small culvert over run, 20 feet south of rail fence, 100 feet east of right angle in road, in small limestone rock; chiseled square, "T. B. M. 1805.0" painted	1,805.19
Greenville, 2.8 miles east of, 70 feet east of small wooden bridge, 10 feet northeast of 12-inch oak tree, 8 feet north of rail fence, 40 feet north of main road, in small limestone rock; bronze tablet stamped "W. Va. 1,738 1920"	1,738.058
Greenville, 1.9 miles northeast of, 600 feet southwest of dwelling house, 30 feet west of rail fence, 200	

Feet.

feet south of right angle in road, on west side of road, in large limestone boulder; chiseled square, "T. B. M. 1,677.5" painted..... 1,677.72

Greenville, 0.7 mile east of, 150 feet south of small unpainted barn, 20 feet west of barbed wire fence, 200 feet south of gate to private lot, on west side of road, in large flat limestone rock; chiseled square, "T. B. M. 1,738.7" painted..... 1,738.91

Greenville P. O., 10 feet from front door of, 40 feet northwest of town reservoir, 30 feet north of right angle in road, in front step of post-office, in large square limestone rock; bronze tablet stamped "W. Va. 1,702" 1,701.768

Greenville, 1.0 mile northwest of, 200 feet northwest of farm house, 100 feet south of intersection of T roads, on west side of road, in limestone abutment (south end) of small culvert; chiseled square, "T.B. M. 1,583.8" painted..... 1,583.994

From Greenville along highways west and south into Pearisburg Quadrangle.

Greenville, 2.6 miles northwest of, 500 feet east of iron bridge over Indian Creek, 120 feet northwest of road intersection, 2 feet west of rail fence, on west side of road running northwest, in root of 8-inch hickory tree; copper nail and washer, "T. B. M. 1,583.2" painted..... 1,583.41

Greenville, 3.2 miles west of, 250 feet west of main road, on south side of D. E. Pence's residence, in stone foundation 1 foot above ground; bronze tablet stamped "W. Va. 1,596 1920"..... 1,596.326

Greenville, 4.2 miles west of, 200 feet east of farm house, 100 feet north of T road west, 10 feet west of rail fence, on west side of road, in root of 12-inch hickory tree; copper nail and washer, painted "T. B. M. 1,618.7"..... 1,618.99

Greenville, 5.5 miles southwest of, 500 feet east of farm house, 100 feet east of T road intersection, 8 feet west of Hands Creek, 200 feet west of left angle in road, on south side of road, in root of 18-inch sycamore tree; copper nail and washer, "T. B. M. 1,604.3" painted..... 1,604.61

Lindside, 6.1 miles northwest of, 250 feet west of Hands Creek, 120 feet south of Sulphur Spring, 100 feet southeast of private gate to lot, 100 feet east of small wooden culvert, 20 feet south of large maple tree, on south side of road, in east end of foundation of Hands Creek Schoolhouse; bronze tablet stamped "W. Va. 1,638 1920"..... 1,638.061

	Feet.
Lindside, 4.8 miles northwest of, 10 feet west of Hands Creek, 100 feet west of right angle in road, 50 feet south of wooden foot-bridge, on south side of road running east and west, in small flint rock; chiseled square, painted "T. B. M. 1,691.0"..	1,691.27

From Pearisburg Quadrangle about 4 miles southwest of Willow Bend, northeast to Willow Bend.

Willow Bend, 3.1 miles southwest of, 500 feet south of farm house, 400 feet south of right angle in road, 50 feet west of run, 20 feet west of 12-inch birch tree, on west side of road, in side of large limestone rock; bronze tablet stamped "W. Va. 1,905 1920"	1,902.604
Willow Bend, 2.1 miles southwest of, 200 feet east of church 80 feet south of left angle in road, 2 feet west of wire fence, on east side of road, in west end of abutment of culvert; copper nail and washer, painted "T. B. M. 2,007.8".....	2,008.07
Willow Bend, 1.2 miles southwest of, 250 feet west of farm house, 50 feet west of 20-inch poplar tree, 100 feet west of small run, on west side of road, in large limestone rock; chiseled square, painted "T. B. M. 1,981.6".....	1,981.95

Primary leveling by E. E. Harris in 1921:

From Union along highways east into Ronceverte Quadrangle.

Union, 0.9 mile east of, on south edge of road, on east edge of driveway to dwelling, in east end of box culvert under driveway; copper nail and washer, marked "T. B. M. 2,199.6".....	2,199.52
Union, 1.7 miles east of, on south edge of road, 30 feet east of lane southwest, on top of large rock boulder; chiseled square, marked on fence railing "T. B. M. 2,233.6".....	2,233.49

Primary leveling by R. G. Stevenson in 1920:

From Greenville along highways northwest to Talcott. This line contains a large unadjusted error.

Greenville, 1.9 miles northwest of, 100 feet north of Indian Draft Creek, 30 feet east of large sycamore tree, 20 feet west of rail fence, on west side of road; chiseled square, "T. B. M. 1,618.7" painted.....	1,618.90
Wayside, 0.6 mile southeast of, about 3.1 miles northwest of Greenville, 120 feet east of residence of G. C. Humphreys, 5 feet east of small drain, 120 feet north of small unpainted barn, on east side of main road, in large limestone boulder; bronze tablet stamped "W. Va. 1,770 1920".....	1,770.287

	Feet.
Wayside P. O., 30 feet south of, 40 feet north of intersection of T road west, 110 feet north of C. A. Allen's store, on west side of road, in root of 12-inch oak tree; copper nail and washer, "T. B. M. 1,990.1" painted	1,990.38
Wayside, 1.0 mile north of, 500 feet northwest of residence of S. L. Vass, 30 feet west of wire fence, 150 feet south of left angle in road, on west side of road, in root of 12-inch apple tree; copper nail and washer, "T. B. M. 2,081.0" painted	2,081.29
Wayside, 1.7 miles north of, about 7 miles southeast of Lowell, at intersection of T road north, 50 feet west of mail box of R. E. Riner, 200 feet east of right angle in road, 30 feet east of sign-board marked "Johnson's Crossroads", on north side of road running east and west, in small limestone rock; bronze tablet stamped "W. Va. 2,119 1920".	2,119.337
Creamery, 1.3 miles southeast of, 500 feet of farm house, 10 feet south of rail fence, 200 feet east of right angle in road, on north side of road, in small limestone rock; chiseled square, painted "T. B. M. 2,101.0"	2,101.31
Creamery, 1,000 feet northeast of, 40 feet east of Kelly Creek, 100 feet west of J. L. Pitzer's residence, 80 feet west of small unpainted barn, on southwest side of road, in small limestone rock; chiseled square, painted "T. B. M. 1,668.8"	1,669.00
Lowell, 2.3 miles southeast, 1.1 miles northwest of Creamery, 125 feet west of T road intersection, 20 feet south of small sycamore tree, in west sandstone abutment of bridge over Kelly Creek; bronze tablet stamped "W. Va. 1,583"	1,583.578
Lowell, 1.2 miles southeast of, 100 feet east of left angle in road, 10 feet north of barbed wire fence, 80 feet southwest of 8-inch maple tree, on south side of road, in small limestone rock; chiseled square, painted "T. B. M. 1,715.0"	1,715.27
Talcott, in east end of south abutment of steel bridge over Greenbrier River; bronze tablet stamped "1,501 B4 1912" (Bulletin No. 632, W. Va.) (Big Bend Quadrangle)	1,501.986

Primary leveling by F. L. Shalibo in 1920:

From Clintonville Quadrangle south along highways to Alderson.

Alderson, 2.2 miles northwest of, near small stream crossing, on east edge of road, in fence line, in large boulder; bronze tablet stamped "W. Va. 1920 1,608"	1,608.016

	Feet.
Alderson, 1.5 miles northwest of, at junction of Keeney's Knob road and River road, in northeast corner of, in ledge of rock; chiseled square, painted "1,537.5"	1,537.30
Alderson, 0.9 mile northwest of, on River road, at southeast corner of iron bridge, on large boulder; chiseled square, painted "1,554.9"	1,554.68
Alderson, in northwest corner of front face of Merchant Grocery Company's building; aluminum tablet stamped "1,556" (Bulletin No. 632, p. 10)	1,555.074

From McGlone P. O., Ronceverte Quadrangle, west along highways to Willow Bend near southeast corner of Quadrangle.

McGlone P. O., 1.3 miles southwest of, 1.9 miles east of Willow Bend, in north corner of triangle at T road, in large boulder; chiseled square, painted "2,061.0"	2,060.82
Willow Bend, 0.7 mile east of, on south edge of road, in front of farm house, in ledge of rock; chiseled square, painted "1,962.2"	1,965.03

BIG BEND QUADRANGLE: MONROE, RALEIGH, AND SUMMERS COUNTIES.

(Latitude 37°30′-37°45′; Longitude 80°45′-81°.)

Primary leveling by L. F. Biggs in 1912:

From point 2.9 miles south of Warford northeast along road to Talcott.

Warford, 2.9 miles south of, in stone chimney of J. H. Dickinson's house; aluminum tablet stamped "1446"	1,446.143
Indian Creek, at mouth of, 150 feet northeast of W. C. Tabor's residence, at north edge of road; chisel point on large boulder, chiseled "1506 U. S."	1,505.68
Indian Mills, 1 mile west of, west edge of road; chisel point on ledge, chiseled "1458 U. S."	1,457.85
Indian Mills, 250 feet north of mouth of Bradshaw Creek, west edge of road, in rock ledge; bronze tablet stamped "1490" BI 1912"	1,490.188
T. G. Lowe's farm house, 600 feet north of, west edge of road; chisel point on slate ledge, painted "1553 U. S."	1,553.41
Forest Hill, 2 miles south of, west edge of road, at T road; copper nail in base of 1-foot oak tree, scribed "1610 U. S."	1,609.67
Forest Hill, 1 mile south of, west edge of road; chisel point on slate ledge, chiseled "1728 U. S."	1,727.97

Feet.

Forest Hill, south edge of road, in front of "M. E. Church," in rock; bronze tablet stamped "1933 B2 1912".. 1,932.899

Forest Hill, 1 mile northeast of, north edge of road, at junction; copper nail in base of 10-inch oak tree, scribed "1906 U. S."..... 1,906.23

Marie, 800 feet south of road junction, west edge of road, at summit of hill; copper nail in base of 2-foot oak tree, scribed "2099 U. S."..... 2,099.18

Greenbrier (Bargers) Springs, 1.3 miles south of, east edge of road, in front of James Garten's farm house; chisel point on rock, chiseled "1673 U. S." 1,672.71

Greenbrier (Bargers) Springs, 0.2 mile west of, at road forks; chisel point on flat rock chiseled "1457 U. S." 1,456.84

Greenbrier (Bargers) Springs, 60 feet south Bargers Springs post-office, south edge of road, in front of A. G. Flanagan's cottage, in flat rock; bronze tablet stamped "1485 B3 1912"..... 1,484.602

Talcott, 1.6 miles south of, summit of hill at road forks; copper nail in base of chestnut tree 1 foot in diameter scribed "1876 U. S."..... 1,876.29

Talcott, in east end of south abutment of steel bridge over Greenbrier River; bronze tablet stamped "1501 B4 1912" 1,501.112

Precise leveling by C. H. Semper in 1909:

From Hinton south along highway to point 1 mile south of Crumps Bottom.

Hinton, in northwest corner of Chesapeake & Ohio Ry. station; aluminum tablet stamped "1336"..... 1,385.212

Bellepoint, 1 mile south of, east of road; point on rock marked "U. S. □ B. M. 1440"..... 1,440.08

Bellepoint, 3.8 miles south of, 350 feet east of road, at J. N. Hayne's farm house, in cement well curb; aluminum tablet stamped "1409"..... 1,408.968

Bellepoint, 5.7 miles south of, in southwest corner of J. H. Blankenship's house; aluminum tablet stamped "1402" 1,402.204

Bellepoint, 6.7 miles south of, west of road, 800 feet south of Webb's house; spike in root of sycamore tree. 1,395.62

Bellepoint, 7.8 miles south of, east of road, 100 feet north of sawmill site; large rock marked "U. S. □ B. M. 1427" 1,426.72

	Feet.
Bellepoint, 8.8 miles south of, in stone chimney of E. F. Farley's house; aluminum tablet stamped "1446".	1,446.136
Warford, 150 feet south of store, east of road; large rock marked "U. S. □ B. M. 1411"	1,410.66
Warford, 1 mile south of, north margin of road; rock 7 by 5 feet marked "U. S. □ B.M. 1453"	1,453.096
Warford, 2.9 miles south of, in stone chimney of J. H. Dickinson's house; aluminum tablet stamped "1446"	1,446.143
Crumps Bottom, in southwest corner of G. W. Harmon's house; aluminum tablet stamped "1510"	1,510.063
Crumps Bottom, 1 mile south of, east margin of road, 450 feet below falls; stone marked "U. S. □ B. M. 1451"	1,451.01

BLUEFIELD QUADRANGLE: MERCER AND SUMMERS COUNTIES.

(Latitude 37°15-37°30′; Longitude 81°-81°15′.)

Precise leveling by T. A. Green in 1909:

From point 1.9 miles west of Oakvale west along Norfolk & Western Ry. to Bluefield.

Hardy, 0.2 mile east of, 250 feet west of mile-post 351, north of railroad, in west edge of sandstone culvert; aluminum tablet stamped "1868"	1,867.860
Hardy, in front of station; top of rail at crossing	1,884.22
Ingleside, 0.8 mile east of, at mile-post 352, on south end of east abutment of railroad bridge 829; chiseled square	1,917.98
Ingleside, in front of station; top of rail	1,950.17
Ingleside, 0.2 mile west of, 300 feet east of mile-post 353, on west end of sandstone culvert; chiseled square	1,959.41
Blake, 200 feet southwest of signal-tower, in south end of east abutment of railroad bridge 832; aluminum tablet stamped "2009"	2,009.607
Ada, 1.6 miles east of, 300 feet west of mile-post 357, north of railroad, 20 feet south of gate across trail, in limestone rock; aluminum tablet stamped "2155"	2,154.887
Ada, in front of station; top of rail	2,223.7
Bluefield, 3.1 miles east of, 100 feet east of mile-post 360, on north side of railroad, in west end of sandstone culvert; aluminum tablet stamped "2331"	2,330.968

Feet.

Bluefield, 2.1 miles east of, 50 feet west of mile-post 361, on rock; chiseled square..... 2,413.20

Bluefield, 100 feet south of station, at front entrance to New Altamont Hotel, in first step above pavement; aluminum tablet stamped "2563"..... 2,563.129

Bluefield, in front of station; top of rail..... 2,558.43

Primary leveling by C. H. Semper in 1909 and K. W. Trimble in 1913:

From Montcalm north along Norfolk & Western Ry. and Virginian Ry. to Giatto.

Montcalm, 1.3 miles north of, 85 feet south of mile-post 10, 180 feet south of south end of tunnel, 20 feet east of track, in large rock; aluminum tablet stamped "2210" 2,210.375

Rock, in front of station; top of rail..... 2,221.1

Rock, 1.8 miles north of, 570 feet north of mile-post 13, east side, south end, in top of railroad culvert; aluminum tablet stamped "2277"..... 2,276.762

Matoaka, 513 feet east of station, in east end of face of south abutment of Virginian Ry. overhead crossing; aluminum tablet stamped "2362"..... 2,362.448

Matoaka, in front of Norfolk & Western Ry. station; top of rail 2,362.6

From Blake north along highways to Kegley, thence southwest along Virginian Ry. to Rock.

Blake, 200 feet west of signal-tower, in south end of east abutment of railroad bridge 832; aluminum tablet stamped "2009" 2,009.607

Ingleside, 0.2 mile west of, 300 feet east of mile-post 353, on west end of sandstone culvert; chiseled square 1,959.41

Ingleside, 1.6 miles north of, at road fork, 7 feet east of Ingleside-Princeton road, on sandstone ledge; chiseled square, marked "2080.6 B. M."..... 2,080.66

Ingleside, 2.5 miles north of, in northeast corner of road fork, on flat sandstone rock; chiseled square, marked "2229.9 B. M." 2,229.98

Ingleside, 3.6 miles north of, 10 feet east of highway, opposite south end of Virginian Ry. tunnel, in sandstone ledge; bronze tablet stamped "2513" (probably moved) 2,513.265

Princeton, 2.2 miles south of, at road fork, top of bolt-head, in floor-rail at northeast corner of wooden bridge; marked "2478.4 B. M."..... 2,478.54

	Feet.
Princeton, 0.8 mile south of, in southwest corner of road fork, on sandstone rock; chiseled square, marked "2391.2 B. M."	2,391.82
Princeton, Mercer County court-house, in center of north face of top concrete step to main entrance; bronze tablet stamped "2449"	2,449.457
Princeton, 1.2 miles northwest of, 20 feet south of road fork, on sandstone ledge; chiseled square, marked "2526.1 B. M."	2,526.04
Princeton, 1.9 miles northwest of, 20 feet southwest of road fork, on sandstone ledge; chiseled square, marked "2347.7 B. M."	2,347.64
Princeton, 2.7 miles northwest of, 250 feet west of road fork, 10 feet south of highway, in sandstone ledge; bronze tablet stamped "2583"	2,583.253
Kegley village, 30 feet south of road fork, 50 feet southeast of blacksmith shop, on sandstone ledge; chiseled square, marked "2442.9 B. M."	2,443.90
Kegley station, 0.5 mile west of, 70 feet southeast of Virginian Ry. grade crossing, 7 feet south of highway, in limestone ledge; bronze tablet stamped "2326"	2,326.405
Kegley station, 1.5 miles west of, 40 feet north of Virginian Ry. crossing, in base of telegraph-pole; copper nail marked "2300.9 B. M."	2,300.87
King station, 0.8 mile east of, at west end of deep cut, 7 feet south of Virginian Ry., on sandstone rock; chiseled square, marked "2275.6 B. M."	2,275.61
King station, opposite; top of rail	2,261.0
King station, 0.2 mile west of, 12 feet south of main track Virginian Ry., 35 feet south of point of frog of two side-tracks, in sandstone rock; bronze tablet stamped "2260"	2,260.218
King station, 1.5 miles west of, 140 feet east of east end of Virginian Ry. tunnel, in top of northeast corner post of cattle-guard; copper nail marked "2246.8 B. M."	2,246.93
Rock, 0.5 mile east of, 290 feet west of mile-post 351, 10 feet north of Virginian Ry., on sandstone rock; chiseled square, marked "2234.7 B. M."	2.233.88
Rock, Virginian Ry. station; top of rail opposite	2,229.9
Rock, Virginian Ry. bridge over Bluestone River, in top of north end of west concrete abutment; chiseled square, marked "2229.3 B. M."	2,228.50

	Feet.
Rock, 1.8 miles north of, 570 feet north of mile-post 13, east side, south end, in top of railroad culvert; aluminum tablet stamped "2277"	2,276.762
From Kegley north along highway to Camp Creek.	
Kegley, 1 mile north of, west end of north abutment to highway bridge over Bluestone River, on bridge seat stone; chiseled square, marked "2084.6 B. M."	2,084.50
Spanishburg, 2.1 miles south of, 60 feet west of schoolhouse, 30 feet east of highway, in top of stump; copper nail marked "2376.7 B. M."	2,376.38
Spanishburg, 0.3 mile west of, in top of north end of west concrete abutment to highway bridge over Bluestone River; bronze tablet stamped "2071"	2,070.960
Spanishburg, 1.1 miles north of, 8 feet north of highway, on sandstone ledge; chiseled square, marked "2432.1 B. M."	2,431.88
Spanishburg, 2.2 miles north of, at right angle bend in highway, 10 feet west of highway, on sandstone rock; chiseled square, marked "2260.0 B. M."	2,259.83
Spanishburg, 3 miles north of, 7 feet east of highway, in sandstone ledge; bronze tablet stamped "2162" ..	2,161.935
Camp Creek, 2 miles south of, 300 feet south of dwelling, 7 feet east of highway, in root of oak stump; copper nail	2,149.77
From Princeton northeast along electric railway grade to Athens, 0.9 mile east of.	
Princeton, Virginian Ry. station; top of rail opposite	2,393.6
Princeton, Virginian Ry. station, 0.2 mile east of, 100 feet north of Hines Lumber Co.'s office, in root of maple tree; copper nail marked "2385.3 B. M." ...	2,384.64
Princeton, 1.8 miles east of, in north end of east floor rail to highway bridge over Christian Fork; copper nail marked "2393.1 B. M."	2,392.51
Princeton, 3.8 miles northeast of, in northeast corner of highway bridge over Dares Creek; copper nail marked "2463.1 B. M."	2,462.50
Princeton, 4.5 miles northeast of, in south side of street railway rock cut, 5 feet above grade, in sandstone rock; bronze tablet stamped "2518"	2,517.004
Athens, 2.5 miles southwest of, 500 feet southwest of schoolhouse, 10 feet south of highway, in base of telephone-pole; copper nail marked "2677.3 B. M."	2,676.55

	Feet.
Athens, 1.9 miles west of, in northwest corner of road fork, in root of black oak tree; copper nail marked "2723.1 B. M."	2,722.43
Athens, in top of north end of concrete step to west entrance of Massie Hotel; bronze tablet stamped "2598"	2,596.926
Athens, 0.9 mile east of, 12 feet north of highway, 15 feet west of small hollow at road fork, on sandstone rock; chiseled square, marked "2445.6 B. M."	2,444.89

BRAMWELL QUADRANGLE: MERCER, McDOWELL, AND WYOMING COUNTIES.

(Latitude 37°15′-37°30 ; Longitude 81°15′-81°30′.)

Primary leveling by T. A. Green, C. H. Semper, and S. E. Taylor in 1909:

From point 1.1 miles east of East Vivian east along Norfolk & Western Ry. to State line.

East Vivian, in front of station; top of rail	1,515.5
East Vivian, 1.1 miles east of, in north end of east abutment of railroad bridge 883; aluminum tablet stamped "1555"	1,554.837
Eckman, in front of station; top of rail	1,593.4
Eckman, 0.3 mile east of, at mile-post 388, north end of east abutment of railroad bridge 880; chiseled square	1,604.00
Keystone, front entrance to Alhambra Hotel, in east end of step above pavement; aluminum tablet stamped "1645"	1,645.311
North Fork, 1 mile east of, 200 feet east of mile-post 385, on north end of bridge seat of west abutment of railroad bridge 874; chiseled square	1,759.96
Powhatan, in front of station; top of rail	1,799.8
Upland, 50 feet south of railroad, at northwest corner of foot-bridge over Elkhorn Creek, 100 feet north of company store; aluminum tablet stamped "1843".	1,843.296
Elkhorn, at mile-post 383, on west end of north abutment of foot-bridge over Elkhorn Creek; chiseled hole	1,881.87
Elkhorn, 1 mile east of, at mile-post 382, on north end of bridge seat of east abutment of railroad bridge 867; chiseled square	1,948.45
Ennis, west of station, at road crossing; top of rail	1,995.9

	Feet.
Ennis, 0.6 mile east of, 950 feet east of mile-post 381, in north end of east abutment of arch over Elkhorn Creek and wagon road; aluminum tablet stamped "2032"	2,031.834
Lick Branch, in front of station; top of rail	2,051.6
Lick Branch, at road crossing just east of company store, in cut; copper bolt marked "B. M. No. 64"	2,058.25
Maybeury, in front of station; top of rail	2,171.0
Coaldale, 350 feet west of post-office, 125 feet east of telegraph station, north of railroad, in sandstone ledge; aluminum tablet stamped "2339"	2,339.416
Coaldale, 0.4 mile east of, at top of divide over long tunnel, 12 feet south of property-line post in center of divide; top of rail section	2,652.00
Ruth, in front of station; top of rail	2,392.3
Ruth, 0.6 mile east of, on southeast corner of concrete foundation for block signal; chiseled square	2,358.23
Cooper, 300 feet west of tunnel, on north end of east abutment of railroad bridge 854; chiseled square	2,309.28
Bluestone, in front of station; top of rail	2,285.3
Bluestone, in north end of east abutment of railroad bridge 851; aluminum tablet stamped "2283"	2,283.248
Nemours, road crossing at mail-crane; top of rail	2,296.5
Nemours, 300 feet west of mile-post 372, in north end of east abutment of railroad bridge 848; aluminum tablet stamped "2300"	2,299.616
Flattop, 300 feet west of mile-post 371, on north end of east abutment of railroad bridge 844; chiseled square	2,309.10
From Cooper northeast along Norfolk & Western Ry. to Montcalm.	
Cooper, 300 feet west of tunnel, on north end of east abutment of railroad bridge 854; chiseled square, marked "No. 44 U. S. B. M. 2309"	2,309.382
Cooper, 0.6 mile north of, 60 feet north of mile-post 2, 4 feet west of track, in side cut; marked square on top of rock	2,264.53
Bramwell, in front of station; top of rail	2,252.7
Simmons, in front of station; top of rail	2 249.6

	Feet.
Simmons, 0.1 mile north of, 20 feet east of track, in top of northwest foundation of water-tank; aluminum tablet stamped "2247"	2,247.330
Flipping, 0.2 mile south of, in top of west abutment on north side of highway bridge over Bluestone River; aluminum tablet stamped "2225"	2,224.777
Flipping, in front of station sign; top of rail	2,220.9
Montcalm, opposite station; top of rail	2,213.8
From Giatto northwest along Virginian Ry. to Micajah tunnel.	
Giatto, in front of station; top of rail	2,373.1
Giatto, 1.1 miles west of, 55 feet west of mile-post 18, 6 feet south of Norfolk & Western Ry., in top of rock; aluminum tablet stamped "2417"	2,416.932
Clark, in south foundation pier of Virginian Ry. water-tank; aluminum tablet stamped "2487"	2,487.121
Clark, in front of station; top of rail	2,522
Clark, 0.7 mile northwest of, 8 feet west of railroad, on sandstone ledge; chiseled square	2,466.93
Clark, 3 miles northwest of, 930 feet west of the west end of Micajah tunnel of Virginian Ry., 15 feet south of railroad, 5 feet south of stone culvert, in sandstone ledge; aluminum tablet stamped "2239 1909"	2,238.689
From Bluestone southwest along Norfolk & Western Ry. branch to State line crossing (part of double line to Pocahontas, Va.).	
Bluestone, in north end of east abutment of railroad bridge 851; aluminum tablet stamped "2283"	2,283.248
Virginia-West Virginia State line crossing, at road crossing, north of long tunnel; top of rail, warning post marked "U. S. 2308"	2,308.0

CLINTONVILLE QUADRANGLE: GREENBRIER AND SUMMERS COUNTIES.

(Latitude 37°45′-38°00 ; Longitude 80°30′-80°45′.)

Primary leveling by F. L. Shalibo in 1920:

From near Fort Spring (Alderson Quadrangle,) north along highways to near Alta, thence northwest to Meadow Bluff, thence south and west to Dawson, thence south and southeast to near Alderson (Alderson Quadrangle).

Fort Spring, 0.9 mile north of, at junction of Davis Creek and Greenbrier River, at right angle turn in road,

	Feet.
on north edge of road, in root of 4-foot oak tree; copper nail, painted "1,602.5"	1,602.52
Fort Spring, 1.5 miles north of, on northwest edge of road, opposite forks at top of hill, in edge of road, 4 feet west of walnut tree; chiseled square, painted "1,798.9"	1,798.87
Fort Spring, 1.9 miles north of, 0.4 mile west of top of hill, in northeast corner of T road north, in large boulder; bronze tablet stamped "W. Va. 1920 1,788"	1,788.371
Fort Spring, 2.8 miles north of, on Davis Hollow road, 0.9 mile north of road forks, on west edge of road, on large boulder; chiseled square, painted "1,998.1"	1,998.11
Fort Spring, 3.6 miles north of, on Davis Hollow road, 0.6 mile southeast of Fort Spring turnpike, near small stream crossing, on west edge of road, on large boulder; chiseled square, painted "2,273.3".	2,273.28
Fort Spring, 4.2 miles north of, at junction of Davis Hollow road and Fort Spring turnpike, 100 feet southeast of road forks, in large boulder; bronze tablet stamped "W. Va. 1920 2,460"	2,459.955
Fort Spring, 5.2 miles north of, on Fort Spring turnpike, 15 feet northeast of **Jones Chapel,** in root of 20-inch oak tree; copper nail, painted "2,587.9"	2,587.89
Jones Chapel, 0.8 mile northeast of, on Fort Spring turnpike, oposite private road northwest, on east edge of road, in ledge of rock; chiseled square, painted "2,499.7"	2,499.69
Jones Chapel, 1.7 miles northeast of, on Fort Spring turnpike, 200 feet south of house, 150 feet north of T road northwest, on west edge of road, in fence line, in top of old stump; copper nail, painted "2,620.5"	2,620.53
Asbury, 3.0 miles east of, about 5.0 miles west of Lewisburg, on Blue Sulphur turnpike, at top of hill, 100 feet west of T road south, on south edge of road, in ledge of rock; bronze tablet stamped "W. Va. 1920 2,583"	2,583.106
Asbury, 2.1 miles east of, on Blue Sulphur turnpike, in northeast corner of T road north, in root of 10-inch maple tree; copper nail, painted "2,516.8"	2,516.83
Asbury, 1.3 miles east of, on Blue Sulphur turnpike, in front of farm house, on north edge of road, in step of stile; copper nail, painted "2,197.4"	2,197.43

	Feet.
Asbury, 150 feet west of T road north, in front of dwelling, on north side of road, in end of cement walk; bronze tablet stamped "W. Va. 1920 2,107".....	2,107.166
Asbury, 0.7 mile north of, in northwest corner of T road northwest, near corner of old shed, in root of 10-inch hickory tree; copper nail, painted "2,191.0"..	2,191.04
Asbury, 1.8 miles north of, 1.9 miles south of **Alta,** in northeast corner of second-class T road east, at north end of gate, in root of 8-inch oak tree; copper nail, painted "2,365.5".....	2,365.60
Asbury, 2.7 miles north of, 1.0 mile south of **Alta,** in northeast corner of school, in stone foundation; bronze tablet stamped "W. Va. 1920 2,462"....	2,461.831
Asbury, 3.7 miles north of, 4.3 miles east of Clintonville, at **Alta,** in southeast corner of road forks, in root of large oak tree; copper nail, painted "2,477.7"..	2,477.78
Clintonville, 3.7 miles east of, 0.6 mile west of **Alta,** in northeast corner of T road north, 30 feet east of pike, in ledge of rock; bronze tablet stamped "W. Va. 1920 2,291".....	2,290.685
Clintonville, 2.5 miles east of, 1.8 miles west of **Alta,** 60 feet east of T road south, at top of hill, on south edge of road, in ledge of rock; chiseled square, painted "2,350.7"	2,350.82
Clintonville, 1.4 miles east of, on north edge of road, opposite T road south, 120 feet east of T road north, in ledge of rock; chiseled square, painted "2,212.6"	2,212.70
Clintonville, opposite store, in southeast corner of foundation of J. M. Farrell's residence; bronze tablet stamped "W. Va. 1920 2,648".....	2,648.500
Clintonville, 0.9 mile west of, at top of hill, opposite T road north, on south side of road, at east end of gate to field, in root of 20-inch oak tree; copper nail, painted "2,561.5".....	2,561.63
Clintonville, 1.7 miles west of, 1.2 miles east of Meadow Bluff, in southwest corner of crossroads, in northeast corner of fence around Sam Black's Memorial M. E. Church, in top of corner post; copper nail, painted "2,425.0"	2,425.24
Meadow Bluff, opposite store, 100 feet south of road, in front of James Osborne's residence, in door-step; bronze tablet stamped "W. Va. 1920 2,461".....	2,460.890
Meadow Bluff, 0.8 mile south of, opposite **St. John's Church,** on west side of road, 1 foot west of fence, in large boulder; chiseled square, painted "2,546.6"	2,546.77

	Feet.
Meadow Bluff, 1.7 miles south of, 0.3 mile north of **Smoot P. O.,** opposite **Blue Spring Baptist Church,** in front of store, on west edge of road, in root of 10-inch oak tree; copper nail, painted "2,461.1"..	2,461.27
Smoot P. O., in front of, on east edge of road, in large boulder; bronze tablet stamped "W. Va. 1920 2,477"	2,477.065
Smoot P. O., 1.0 mile west of, opposite old mill, in triangle of T road north, in root of 10-inch oak tree; copper nail, painted "2,468.7".....	2,468.86
Smoot P. O., 1.7 miles west of, 2.4 miles northeast of **Dawson,** 40 feet southwest of T road, on fence line, on south edge of, in old telephone pole; copper nail, painted "2,508.0"	2,508.11
Smoot P. O., 2.4 miles west of, 1.7 miles northwest of **Dawson,** in front of S. D. McClung's residence, 15 feet north of road, 3 feet north of fence, in root of 14-inch apple tree; copper nail, painted "2,451.9"	2,452.01
Smoot P. O., 3.3 miles west of, 0.8 mile north of **Dawson,** on west edge of road at three corners, in root of 4-foot oak tree; copper nail, painted "2,432.8"....	2,432.90
Dawson, 200 feet south of corners, opposite store, in base of chimney, on west side of J. F. Cooke's residence; bronze tablet stamped "W. Va. 1920 2,432".	2,430.525
Dawson, 1.3 miles southeast of, in southwest corner of T road south, 300 feet west of Knapp School, in root of 16-inch oak tree; copper nail, painted "2,443.6"	2,443.71
Dawson, 2.2 miles south of, 1.1 miles north of **Grassy Meadows,** at sharp angle on west edge of road near gate to farm house, in rail fence corner, on small stone; chiseled square, painted "2,442.9"..	2,443.00
Grassy Meadows, back of J. E. Leaf's residence, in southeast corner of cellar wall; bronze tablet stamped "W. Va. 1920 2,449"	2,449.531
Grassy Meadows, 1.2 miles southeast of, at three corners, on east edge of road, in large boulder; chiseled square, painted "2,459.3"	2,459.29
Grassy Meadows, 2.6 miles south of, at sharp bend, 50 feet south of wooden bridge, in boulder; chiseled square, marked "2,306.4"	2,306.43
Snake Run (Cleveland) School, 250 feet north of, at southeast corner of ledge of rock; bronze tablet stamped "W. Va. 1920 2,010".....	2,010.273

	Feet.
Snake Run (Cleveland) School, 0.9 mile south of, on "Keeney's Knob" road, on south edge of road, in large boulder; chiseled square, painted "2,277.5".	2,277.41
Snake Run (Cleveland) School, 2.0 miles southwest of, on "Keeney's Knob" road, 25 feet southeast of **Mt. Vernon School,** in root of large tree; copper nail, painted "2,701.8"	2,701.74
Alderson, 5.6 miles northwest of, near top of "Keeney's Knob" road, in stone chimney, on south side of Stevenson's residence; bronze tablet stamped "W. Va. 1920 2,817"	2,816.877
Alderson, 4.8 miles northwest of, on "Keeney's Knob" road, 0.8 mile south of top, on east edge of road, in ledge of rock; chiseled square, painted "2489.2"	2,489.08
Alderson, 3.9 miles north of, on "Keeney's Knob" road, in triangle at three corners, in root of large oak tree; copper nail, painted "2,036.8"	2,036.68

FLATTOP QUADRANGLE: MERCER, RALEIGH, AND SUMMERS COUNTIES.

(Latitude 37°30′-37°45′; Longitude 81°-81°15′.)

Primary leveling by E. E. Witherspoon and Fred McLaughlin in 1911:

From Camp Creek north along highway to point 6 miles south of Ghent.

Camp Creek, in top of east end of south concrete abutment to highway bridge over Camp Creek; bronze tablet stamped "1975"	1,974.258
Ghent, 6.1 miles south of, 500 feet southeast of house, east side of road, at sharp turn to west, in ledge of rock; bronze tablet stamped "2751"	2,749.693

MEADOW CREEK QUADRANGLE: FAYETTE, GREENBRIER, RALEIGH, AND SUMMERS COUNTIES.

(Latitude 37°45′-38°; Longitude 80°45′-81°.)

Primary leveling by L. F. Biggs in 1912:

From point 0.3 mile south of Sandstone (New Richmond Post-office) east up Laurel Creek 6 miles (double-spur line).

Sandstone, 0.3 mile east of, west side of railroad bridge, in north abutment; aluminum tablet stamped "1292"	1,291.732
Sandstone, 0.9 mile east of, south edge of road, 1,000 feet west of road forks; copper nail in base of 18-inch oak tree, scribed "1536 U. S."	1,536.18

Feet.

Sandstone, 2 miles east of, east edge of road, 1,300 feet west of schoolhouse, east edge of creek, 300 feet west of J. B. Johnson's house; chisel point on boulder, chiseled "1496 U. S."..... 1,495.80

Sandstone, 3.3 miles southeast of, 1.2 miles northwest of **Ramp**, east edge of road, in face of rock; bronze tablet stamped "1682 B 1912"..... 1,682.441

Ramp, east edge of road, 50 feet east of post-office; chisel point on rock, chiseled "1754 U. S."..... 1,753.97

Ramp, 0.4 mile east of, north edge of road, at forks; chisel point on rock, chiseled "1808 U. S."..... 1,808.31

Ramp, 1.3 miles east of, south edge of road, 200 feet east of G. B. Kesler's farm house, north edge of creek, in rock; bronze tablet stamped "1920 B 1912".... 1,920.067

From Meadow Creek northeast along road up Meadow Creek to Springdale, thence northwest to Sewell.

Meadow Creek, 0.2 mile west of, in top of west abutment at north side of railroad bridge; aluminum tablet stamped "1269" 1,270.126

Meadow Creek, 1 mile northeast of, 10 feet east of track; chisel point on ledge, chiseled "1400 U. S."..... 1,399.93

Beurytown, 0.3 mile northeast of, 20 feet west of track; spike in base of telephone-pole, scribed "1556 U. S." 1,556.17

Tina, 0.6 mile southwest of, south edge of track; chisel point on boulder, chiseled "1776 U. S."..... 1,775.66

Tina, 0.4 mile southwest of, 20 feet west of track, at road crossing, 150 feet north of schoolhouse, 150 feet north of switch, in boulder; bronze tablet stamped "1868 B 1912" 1,867.723

Tina, 0.9 mile northeast of, 200 feet south of first switchback, east edge of track; chisel point on boulder, chiseled "2021 U. S." 2,020.92

Meadow Bridge, 1 mile southwest of, west end of south abutment of culvert; chisel point, chiseled "2239 U. S." 2,238.72

Meadow Bridge, 20 feet northeast of station, 20 feet west of road crossing, in large boulder; bronze tablet stamped "2422 B 1912" 2,421.507

Meadow Bridge, 1.1 miles northeast of, 250 feet north of switch, at road crossing; chisel point on boulder, chiseled "2503 U. S." 2,502.55

Springdale, 0.7 mile southwest of, south side of track, at west end of hill; chisel point on rock, chiseled "2721 U. S." 2,721.18

	Feet.
Springdale, 300 feet east of station, south edge of public road, in ledge; bronze tablet stamped "2770 B 1912"	2,769.841
Springdale, 1.1 miles northwest of, north side of road; oak tree 1 foot in diameter at fence, scribed "3044 U. S."	3,044.15
Springdale, 2.2 miles northwest of, west edge of road; nail in root of 3½-foot oak tree, scribed "3176 U. S."	3,176.06
Springdale, 3 miles northwest of, on stone stoop of **Quinton School**; chisel point, chiseled "3059 U. S."	
Springdale, 3.5 miles northwest of, 650 feet west of S. T. Gilkeson's blacksmith shop, north edge of road, in large ledge; bronze tablet stamped "3244 B 1912".	3,244.018
S. T. Gilkeson's blacksmith shop, 0.9 mile northwest of, 500 feet west of forks of road, west edge of road; nail in root of 2-foot chestnut tree, scribed "3245 U. S."	3,244.97
Danese, 1.7 miles southeast of, at forks of road leading south; nail in root of 1-foot white oak tree, marked "2978 U. S."	2,977.39
Danese, 0.6 mile southeast of, east edge of road; nail in root of 2-foot oak tree, scribed "2702 U. S."	2,701.88
Danese, 100 feet east of, 40 feet north of Lady Hall Sub. Dist. No. 5 school building, south edge of road, in ledge; bronze tablet stamped "2637 B 1912"	2,636.896
Maplewood, 0.9 mile south of, south edge of road, where road turns to right, 25 feet north of **Maplewood Chapel** (Methodist Episcopal Church); chisel point on cement walk, chiseled "2705 U. S."	2,704.53
Maplewood, 50 feet south of post-office, south edge of road, at road forks; chisel point on rock, chiseled "2717 U. S."	2,716.58
Maplewood, 0.6 mile northwest of, 200 feet north of railroad right of way, west edge of road; chisel point on boulder, chiseled "2618 U. S."	2,617.68
Maplewood, 1.6 miles west of, at forks of road to S. E. Gwinn's farm house, south edge of road; nail in root of 1-foot sourwood tree, scribed "2872 U. S."	2,871.83
Landisburg, 1.9 miles southeast of, 300 feet west of S. E. Gwinn's farm house, south edge of road; chisel point on boulder, chiseled "2769 U. S."	2,768.46
Landisburg, 800 feet south of, 20 feet north of track, in ledge; bronze tablet stamped "2365 B 1912"	2,364.577

	Feet.
Landisburg, in front of post-office; top of rail.....	2,349.2
Landisburg, 1.9 miles north of, at summit of hill, south edge of track, 100 feet west of road crossing; nail in root of 1-foot chestnut tree, scribed "2417 U. S."	2,416.89
Clifftop, 1.9 miles southwest of, west edge of road; nail in root of 12-inch oak tree, scribed "2097 U. S."...	2,096.52
Clifftop, 2.6 miles southwest of, 100 feet west of railroad bridge over Glade Creek, south side of creek, 20 feet west of water-tank, in face of cliff; bronze tablet stamped "1967 B 1912".....	1,967.059
Sewell, 3.2 miles east of, south edge of road; chisel point on boulder, chiseled "1854 U. S."	1,853.33
Sewell, 2.1 miles east of, south edge of road; chisel point on boulder, chiseled "1625 U. S.".....	1,624.52

PEARISBURG QUADRANGLE: MONROE COUNTY.

(Latitude 37°15′-37°30′; Longitude 80°30′-80°45′.)

Primary leveling by R. G. Stevenson in 1920:

From point on north border of Quadrangle 4 miles northwest of Lindside, south to Lindside, thence southwest along Peterstown road to west border of Quadrangle.

Lindside, 3.8 miles northwest of, 400 feet east of Blue Lick Creek, 100 feet south of right angle in road, 50 feet south of small wooden culvert, 40 feet northwest of gate to lot, on east side of road, in small sandstone rock; chiseled square, painted "T. B. M. 1,797.7"	1,798.01
Lindside, 2.5 miles northwest of, 100 feet north of right angle in road, 150 feet northwest of drain crossing, 100 feet north of gate to private lot, 20 feet east of rail fence, on east side of road, in small limestone rock; bronze tablet stamped "W. Va. 1,917 1920"	1,917.044
Lindside, 1.2 miles northwest of, 200 feet north of farm house, 20 feet south of private gate to lot, 80 feet south of small drain crossing road, 50 feet west of rail fence, on west side of road, in root of 2-foot oak tree; copper nail and washer, painted "T. B. M. 1,976.4"	1,976.80
Lindside, 0.7 mile southwest of, 50 feet east of intersection of T road, 30 feet south of wooden culvert, on south side of road, on top of oak fence 4 feet high; copper nail and washer, "T. B. M. 1,938.8" painted	1,939.18

	Feet.
Lindside, 1.9 miles southwest of, 150 feet southwest of T road intersection, 20 feet west of farm house of E. Wickline, 50 feet north of wire fence, on north side of road, in large root of 3.5-foot oak tree; copper nail and washer, painted "T. B. M. 1,887.3"	1,887.73
Lindside, 2.9 miles southwest of, 200 feet south of right angle in road, on north side of road, on top of concrete rail of bridge over Rich Creek (west wing); bronze tablet stamped "W. Va. 1,840 1920"	1,840.558
Lindside, 4.1 miles southwest of, 500 feet northeast of farm house, 10 feet east of wire fence, 30 feet east of 15-inch apple tree, on north side of road, in small limestone rock; chiseled square, painted "T. B. M. 1,852.8"	1,853.23

From Lindside northeast along highways through north part of Quadrangle into Alderson Quadrangle.

Lindside P. O., on south side of post-office building, in concrete retaining wall to cellar step; bronze tablet stamped "W. Va. 1,994"	1,993.983
Lindside, 1.1 miles northeast of, 2,000 feet northeast of T road intersection, 40 feet east of small wooden culvert, 30 feet south of wire fence, 100 feet east of 18-inch poplar tree, on south side of road, in small limestone rock; chiseled square, painted "T. B. M. 2,011.8"	2,012.14
Lindside, 2.2 miles northeast of, 30 feet north of wire fence, 100 feet west of small cherry tree, on north side of road, in small limestone rock; chiseled square, painted "T. B. M. 2,048.4"	2,048.77
Lindside, 3.1 miles northeast of, on south end of house of L. A. Ellison, in west end of stone chimney; bronze tablet stamped "W. Va. 2,036 1920"	2,035.945
Rock Camp, 0.8 mile southwest of, 400 feet east of farm house, 20 feet north of rail fence, on north side of road, in root of 18-inch oak tree; copper nail and washer, painted "T. B. M. 1,885.6"	1,885.94
Rock Camp P. O., 450 feet north of, 40 feet north of T road intersection, 120 feet northwest of church, 2 feet south of wire fence, 80 feet south of small run, on north side of road running east and west, in large sandstone rock; chiseled square, painted "T. B. M. 1,813.8"	1,814.06

PETERSTOWN QUADRANGLE: MERCER, MONROE, AND SUMMERS COUNTIES.

(Latitude 37°15′-37°30′; Longitude 80°30′-80°45′.)

Precise leveling by C. H. Semper in 1909:

From point 1 mile south of Crumps Bottom south along highway to Glenlyn, Va., thence west along Norfolk & Western Ry. to point 1.9 miles west of Oakvale.

	Feet.
Crumps Bottom, 2 miles south of, east margin of road, 75 feet north of very large boulder; rock 5 by 5 feet marked "U. S. □ B. M. 1441"	1,441.36
Mercer salt well, 40 feet south of road leading into store yard, in center of highway, in large stone; aluminum tablet stamped "1470"	1,470.466
Mercer, 2 miles south of salt works, on west margin of road, 300 feet north of log house and barn; rock marked "U. S. □ B. M. 1483"	1,483.39
Mercer, 3.2 miles south of salt works, 10 feet southeast of Dicks Hollow crossing, 250 feet north of L. R. French's house, on west margin of road, in top of sandrock; aluminum tablet stamped "1510"	1,510.007
Mercer, 5.3 miles south of salt works, at **Bluff** post-office boat landing, 20 feet west of river, 15 feet east of highway, in large flat rock; aluminum tablet stamped "1466"	1,465.931
Mercer, 6.3 miles south of salt works, 500 feet south of State line, on west margin of highway by small drain; low stone marked "U. S. □ B. M. 1490"	1,489.880
Mercer, 8.4 miles south of salt works, 1,400 feet south of schoolhouse, east margin of road; square cut on rock marked "U. S. B. M. 1496"	1,495.83
Mercer, 8.7 miles south of salt works, in southwest corner of Dr. G. A. Shumate's brick house; aluminum tablet stamped "1571"	1,571.564
Mercer, 10.3 miles south of salt works, at east end of old railroad grade, where grade crosses highway, on west margin of road; large rock marked "U. S. □ B. M. 1505"	1,504.65
Wills, in front of station; top of rail	1,624.5
Glenlyn, 3 miles west of, 100 feet west of mile-post "C 364," in top of north end on east side of bridge abutment; aluminum tablet stamped "1644"	1,643.830
Oakvale, in front of station; top of rail	1,712.2

	Feet.
Oakvale, 45 feet west of station, 20 feet north of track, in top of railroad culvert; aluminum tablet stamped "1712"	1,712.199
Oakvale, 1.9 miles west of, 2.3 miles east of **Hardy**, opposite mile-post "C 358", 2 feet north of east-bound rack; top of rail set vertically in ground	1,782.35

Primary leveling by K. W. Trimble and H. S. Senseney in 1913:

From point near Athens northeast along highways to Mercers Saltworks.

Athens, 2.1 miles northeast of, at road fork, 25 feet east of fording, 10 feet north of highway, in root of stump; copper nail, marked "2320.6 B. M."	2,319.86
Pettry Post-office, 50 feet west of southwest corner of store, 70 feet east of southeast corner of church, in sandstone rock; bronze tablet stamped "2567".	2,566.202
Pettry, 0.9 mile northeast of, 7 feet north of highway, on sandstone ledge; chiseled square, marked "2500.7 B. M."	2,499.99
Pettry, 1.9 miles northeast of, 8 feet north of highway, in base of telephone-pole; copper nail, marked "2369.0 B. M."	2,368.28
Tophet Post-office, 1.1 miles west of, 7 feet north of highway, in sandstone ledge; bronze tablet stamped "2170"	2,169.063
Tophet Post-office, 160 feet north of, 10 feet east of highway, in root of oak tree; copper nail, marked "2005.6 B. M."	2,005.85
Mercers Saltworks, 1.9 miles west of, in northeast corner of road fork, on sandstone ledge; chiseled square, marked "1555.4 B. M."	1,555.59
Mercer salt well, 40 feet south of road leading into store yard, in center of highway, in large stone; aluminum tablet stamped "1470"	1,470.466

From Mercers Saltworks along highways east to Cashmere, thence southwest to Glenlyn. (See Virginia list for portion of this line.)

Fergerson's (Shanklins) Ferry, 0.5 mile south of, west side of road on ledge; chiseled square	1,568.41
Fergerson's (Shanklins) Ferry, 1.5 miles southeast of, 10 feet south of forks of road, east side of road, on rock; painted circle	1,851.93
Neponset, north side of road, top of hill, in root of tree; copper nail with washer, stamped "U. S. G. S. W. Va. B. M."	2,036.32

	Feet.
Chestnut Hill, 10 feet south of store, at gate, in stone; bronze tablet stamped "2213"	2,213.598
Chestnut Hill, 1.1 miles east of, northeast corner of cross-roads, in fence post; nail	2,081.97
Cashmere, 0.8 mile west of, 10 feet east of gate, south side of road, on stone; chiseled square	2,060.05
Cashmere, 0.3 mile south of, east corner of south abutment of bridge; bronze tablet stamped "1918"	1,918.256
Cashmere, 1.1 miles south of, east side of road, 60 feet north of summit, in root of tree; copper nail with washer, stamped "U. S. G. S. W. Va. B. M. 2077".	2,076.530
Cashmere, 2.2 miles south of, 450 feet south of forks of road, west side of road, at gate, in root of tree; copper nail and washer, stamped U. S. G. S. W. Va. B. M. 1935"	1,935.05
Cashmere, 2.3 miles south of, 990 feet south of forks of road, east side of road, 4 feet west of fence, in ledge; bronze tablet stamped "1922"	1,921.593
Peterstown, 1.5 miles north of, northwest corner of forks of road, in telephone-pole; nail	1,788.67
Peterstown, northwest corner of First National Bank, 2 feet south of doorway; bronze tablet stamped "1612"	1,611.684

Primary leveling by R. G. Stevenson in 1920:

From east border of Quadrangle southeast along Rich Creek to Peterstown.

Peterstown, 3.2 miles northeast of, 200 feet southeast of residence of Mr. Hansbarger, 10 feet east of wire fence, 5 feet west of south end of stone wall, on west side of road, in root of 2-foot oak tree; copper nail and washer, painted "T. B. M. 1,917.5".	1,917.96
Peterstown, 1.9 miles northeast of, 80 feet west of residence of H. Spangler, 700 feet north of right angle in road, 50 feet east of rail fence, on east side of road, in south end of concrete walk; bronze tablet stamped "W. Va. 1,793 1920"	1,793.962
Peterstown, northwest corner of First National Bank, 2 feet south of doorway; bronze tablet stamped "1,612"	1,611.684

RONCEVERTE QUADRANGLE: GREENBRIER AND MONROE COUNTIES.

(Latitude 37°30′-37°45′; Longitude 80°15′-80°30′.)

Primary leveling by F. L. Shalibo in 1920:

From Ronceverte south along highways to Second Creek P. O., thence northeast along highways via Glace to Tuckahoe.

	Feet.
Ronceverte, in front face of First National Bank Building; aluminum tablet stamped "1,666" (B. 632, p. 10)..	1,665.036
Ronceverte, 1.0 mile south of, on mountain road, opposite T road west, 10 feet east of road, on bank, in root of small tree; copper nail, painted "1,851.8"....	1,851.79
Ronceverte, 2.0 miles south of, on mountain road, in northwest corner of T road west, in root of old stump; copper nail, painted "2,256.2"	2,256.19
Ronceverte, 2.7 miles south of, at road forks, at top of mountain, 20 feet northwest of forks, on north edge of road; bronze tablet stamped "W. Va. 1920 2,417"	2,416.771
Ronceverte, 3.5 miles south of, 0.6 mile northwest of Organ Cave P. O., in northeast corner of cross-roads, in root of large oak tree; copper nail, painted "2,246.4"	2,246.39
Organ Cave P. O., at northeast corner of post-office building, on top of stone hitching post; chiseled square, painted "2,196.8".....	2,196.80
Organ Cave P. O., 0.9 mile south of, on east edge of road in front of farm house, near yard gate, in root of large oak tree; copper nail, painted "2,224.5"...	2,224.50
Second Creek P. O., 2.8 miles north of, 60 feet north of road forks, on east edge of road, in large rock; bronze tablet stamped "W. Va. 1920 2,062".....	2,061.746
Second Creek P. O., 1.6 miles north of, on northwest corner of cement bridge over Second Creek; chiseled square, painted "1,825.7".....	1,825.68
Second Creek P. O., 0.3 mile north of, in northeast corner of J. W. Reed's grist mill; bronze tablet stamped "W. Va. 1920 1,862"	1,862.427
Second Creek P. O., 0.9 mile east of, on second-class road along Second Creek, on north edge of road, near old sawmill site, in root of old stump; copper nail, painted "1,909.2"	1,909.13
Second Creek P. O., 1.3 miles southeast of, at T road west, 100 feet north of house, on north edge of county road, in root of small tree; copper nail, painted "1,933.2"	1,933.17

Feet.

Second Creek P. O., 1.9 miles southeast of, on county road, 20 feet north of ford, 40 feet north of road forks, 20 feet west of road, in rock; bronze tablet stamped "W. Va. 1920 1,950" 1,950.76

Second Creek P. O., 2.8 miles southeast of, on Laurel Creek, 1 mile east of mouth, on old tram road, in root of large oak tree; copper nail, painted "2,011.6" 2,011.62

Glace, 6.6 miles southwest of, on Laurel Creek, 2.1 miles east of mouth, on south edge of creek and north edge of trail, on top of old stump; copper nail, painted "2,099.5" 2,099.46

Glace, 5.4 miles southwest of, on Laurel Creek, 1.3 miles south of public road, at old lumber camp, 50 feet southeast of old chimney, in small rock; bronze tablet stamped "W. Va. 1920 2,212" 2,212.342

Glace, 4.1 miles southwest of, in southwest corner of road forks, 300 feet north of sawmill, in root of pine tree; copper nail, painted "2,322.5" 2,322.44

Glace, 3.8 miles west of, 150 feet east of road forks, at south end of foot-bridge, in root of pine tree; copper nail, painted "2,337.5" 2,337.46

Glace, 2.5 miles west of, 500 feet east of sawmill, 10 feet north of creek, 50 feet north of road, in front of farm house; bronze tablet stamped "W. Va. 1920 2,464" 2,463.839

Glace, 1.6 miles west of, at T road forks, of T road west, at stream crossing, on east edge of road, on large boulder; chiseled square, painted "2,592.0" 2,591.99

Glace, 0.7 mile west of, at foot of hill, 30 feet east of road forks of T road north, in root of old stump; copper nail, painted "2,600.6" 2,600.57

Glace, at southeast corner of store, 50 feet north of road forks, in cement post; bronze tablet stamped "W. Va. 1920 2,568" 2,567.876

Glace, 1.0 mile northeast of, at foot of hill, at T road northwest, 20 feet east of road, near fence line, in root of old stump; copper nail, painted "2,517.0" 2,516.95

Glace, 2.1 miles northeast of, 20 feet north of road, in front of house, at fence line, in root of small maple tree; copper nail, painted "2,367.6" 2,367.54

Glace, 3.2 miles northeast of, 3.9 miles southwest of **Tuckahoe**, in front of house, 50 feet north of gate, along fence line, 30 feet west of road, in small rock; bronze tablet, stamped "W. Va. 1920 2,257" 2,257.007

	Feet.
Tuckahoe, 2.9 miles southwest of, 4.2 miles northwest of **Glace,** in front of house, on north edge of road, in root of tree; copper nail, painted "2,171.8".....	2,171.72
Tuckahoe, 2.3 miles southwest of, 150 feet west of **Tuckahoe School,** 20 feet east of road, in creek bed, in root of small tree; copper nail, painted "2,126.3"	2,126.25
Tuckahoe, 1.3 miles southwest of, in front of store, on north edge of road, along fence line, in root of old stump; copper nail, painted "2,078.4".....	2,078.32
Tuckahoe, 500 feet northwest of station, on Chesapeake and Ohio Railroad, 30 feet south of track, in southwest corner-stone of arch, in coping; bronze tablet stamped "W. Va. 1920 2,024".....	2,024.090
From near Second Creek P. O. along highways south and west into Alderson Quadrangle near its southeast corner.	
Second Creek P. O., 1.9 miles southeast of, on county road, 20 feet north of ford, 40 feet north of road forks, 20 feet west of road, in rock; bronze tablet stamped "W. Va. 1920 1,950".....	1,950.276
Second Creek P. O., 2.9 miles southeast of, on county road, 3.1 miles north of **Hollywood,** 10 feet from stream crossing, on west edge of road, in ledge of rock; chiseled square, painted "2,001.0".....	2,000.92
Hollywood, 2.1 miles north of, on county road, 5 feet west of road, 0.3 mile south of old mill, in root of tree; copper nail, painted "2,066.9"	2,066.89
Hollywood, 0.9 mile north of, on county road, at top of mountain, near field gate, 10 feet east of road, in root of stump; copper nail, painted "2,375.9"....	2,375.82
Hollywood, in northwest corner of stone foundation of woolen-mill; bronze tablet stamped "W. Va. 1920 2,176"	2,176.228
Hollywood, 1.0 mile south of, 300 feet north of house, on east edge of road, in fence line, in root of maple tree; copper nail, painted "2,266.7".....	2,266.69
Hollywood, 2.3 miles south of, in center of triangle at road forks, in small rock; chiseled square, painted "2,378.6"	2,378.56
Gap Mills, 3.0 miles northwest of, 3.1 miles south of **Hollywood,** on Sweet Springs turnpike, in west corner of T road southwest, 15 feet southwest of road, in fence line, in top of cement post; bronze tablet stamped "W. Va. 1920 2,424".....	2,423.614
Gap Mills, 1.7 miles north of, at **Red Mill.** in northeast corner of road forks, 2 feet from yard fence	

	Feet.
corner, in small rock; chiseled square, painted "2,320.8"	2,320.72
Gap Mills, 0.7 mile north of, 60 feet north of road forks, on west edge of road, 3 feet from fence, in root of apple tree; copper nail, painted "2,312.5"	2,312.48
Gap Mills, 150 feet south of stream crossing, in northeast corner of cement stile, in front of Dr. Ballard's residence; bronze tablet stamped "W. Va. 1920 2,343"	2,343.086
Gap Mills, 1.0 mile south of, 600 feet north of Neal's store, 150 feet north of residence, in fence line, in root of tree; copper nail, painted "2,394.2"	2,394.14
Gap Mills, 2.0 miles south of, in southwest corner of road forks, in root of large oak tree; copper nail, painted "2,486.2"	2,486.12
Gap Mills, 3.1 miles south of, on west edge of road, at sharp angle in road, 10 feet east of fence, in root of tree; copper nail, painted "2,613.4"	2,613.31
Gap Mills, 3.7 miles southwest of, at top of divide, opposite T road south over Peters Mountain, in large rock; bronze tablet stamped "W. Va. 1920 2,653"	2,652.549
Gap Mills, 4.4 miles southwest of, 2.4 miles northeast of **McGlone Post-Office,** in northwest corner of T road southwest, 60 feet north of small building, in large boulder; chiseled square, painted "2,411.9"	2,411.63
McGlone P. O., 1.5 miles northeast of, on second-class road, about 0.2 mile west of road fork, at base of wooden gate-post, on north edge of road; copper nail painted "2,299.7"	2,299.57
McGlone P. O., 300 feet northwest of, at northwest corner of W. T. McGlone's residence, in cement post; bronze tablet stamped "W. Va. 1920 2,157"	2,157.034

Primary leveling by F. L. and C. F. Shalibo in 1920.

From Red Mill along highways 10 miles northeast, thence southeast to point 1 mile northwest of Sweet Springs in Craigs Creek Quadrangle.

Gap Mills, 1.7 miles north of, at **Red Mill,** in north corner of road forks, 2 feet from yard fence corner, in small rock; chiseled square, painted "2,320.8"	2,320.72
Red Mill, 1.1 miles northeast of, on north edge of road, 40 feet from stream crossing, 120 feet north of house, in root of tree; copper nail, painted "2,408.8"	2,408.76

	Feet.
Red Mill, 2.3 miles northeast of, 50 feet south of stream crossing at Devil Creek, 50 feet south of footbridge on east edge of road, in large rock; bronze tablet stamped "W. Va. 1920 2,289"	2,288.750
Red Mill, 3.4 miles northeast of, on Devil Creek, 2.4 miles east of main road, on north side of old trail, in root of large pine tree; copper nail, painted "2,382.0"	2,381.99
Red Mill, 4.6 miles northeast of, 1.2 miles southwest of main road, 0.35 mile west of mountain cabin, on north side of old trail, in root of pine tree; copper nail, painted "2,481.8"	2,481.77
Red Mill, 5.8 miles northeast of, 4.0 miles east of **Gap Mills,** 3.5 miles southwest of **Pedro P. O.,** at junction of log road and main road, 10 feet north of road, in rock; bronze tablet stamped "W. Va. 1920 2,536"	2,536.146
Sweet Springs, 9.1 miles northwest of, on county road, 0.8 mile south of road to southwest, 300 feet south of house, 30 feet west of road, in old stump; copper nail, painted "2,527.2"	2,527.20
Sweet Springs, 8.1 miles northwest of, on county road, on south edge of road, near fence, 300 feet north of house, in root of old stump; copper nail, painted "2,457.8"	2,457.74
Sweet Springs, 6.9 miles northwest of, on county road, 0.24 mile west of **Pedro P. O.,** 70 feet south of road, in field, 200 feet south of old house, in large boulder; bronze tablet stamped "W. Va. 1920 2,346"	2,345.624
Sweet Spring, 6.0 miles northwest of, on county road, 0.7 mile east of **Pedro P. O.,** 30 feet south of road near fence line, in root of large oak tree; copper nail, painted "2,309.8"	2,309.74
Sweet Springs, 5.4 miles northwest of, on county road, 1.3 miles east of **Pedro P. O.,** at road forks of T road northeast to Tuckahoe, on south edge of wooden bridge in wooden abutment; copper nail, painted "2,222.2"	2,222.17
Sweet Springs, 4.3 miles northwest of, on Cove Creek road, on west side of road, 30 feet north of stream crossing, in root of large pine tree; copper nail, painted "2,108.2"	2,108.14
Sweet Springs, 3.6 miles northwest of, on Cove Creek road, 15 feet west of road, near junction of old woods road and main road, 200 feet north of small wooden bridge over stream, in large rock; bronze tablet stamped "W. Va. 1920 2,037"	2,036.411

Feet.

Sweet Springs, 2.2 miles northwest of, on Cove Creek road, at road forks, 20 feet east of ford, in southwest corner of forks, in root of small tree; copper nail, painted "1,909.5" 1,909.38

Sweet Springs, 1.0 mile northwest of, on Cove Creek road, 30 feet west of road, on west side of fence, 40 feet south of small bridge on top of large stump; copper nail, painted "2,120.3" 2,120.19

Primary leveling by C. F. Shalibo in 1920:

From point in Virginia 3 miles west of Paint Bank, southwest along Potts Valley Railroad to point 3.3 miles northeast of Waiteville, in Waiteville Quadrangle.

Laurel Branch, 1.7 miles east of, on Potts Valley Railroad at siding, 150 feet west of house, on north edge of timber of switch; copper nail, painted "1,992.3".. 1,992.22

Laurel Branch, 0.7 mile east of, on Potts Valley Railroad, 300 feet west of field gate, 30 feet south of track, on large rock; chiseled square, painted "2,019.6". 2,019.46

Laurel Branch, 40 feet north of station, 10 feet west of road, in large boulder; bronze tablet stamped "W. Va. 1920 2,057" 2,051.801

Laurel Branch, 1.0 mile west of, on Potts Valley Railroad, 40 feet south of track, at east end of field gate, in wooden post; iron bolt, painted "2,064.8"..... 2,064.72

Laurel Branch, 1.9 miles west of, on Potts Valley Railroad, at southwest edge of railroad bridge over small stream, 20 feet from foot-bridge over Potts Creek, in wooden support; copper nail, painted "2,089.6". 2,089.46

Laurel Branch, 3.0 miles west of, on Potts Valley Railroad, 20 feet north of track, on bank opposite mile-post No. 29, 150 feet south of **Patton Schoolhouse,** 40 feet northeast of small railroad bridge, in large rock; bronze tablet stamped "W. Va. 1920 2,124". 2,124.114

From point 3.0 miles north of Waiteville in Waiteville Quadrangle along highways north to point 3.7 miles south of Gap Mills.

Waiteville, 4.2 miles north of, on road to Gap Mills, 1.1 miles from top of mountain, on south edge of road, in top of stump; copper nail, painted "3,122.8" 3,123.70

Waiteville, 5.3 miles north of, on Gap Mills road, at top of **Peters Mountain,** 30 feet east of road, in small boulder; bronze tablet stamped "W. Va. 1920 3,452" 3,451.497

Gap Mills, 5.1 miles south of, on road over Peters Mountain, 0.9 mile from top of mountain, at sharp

Feet.

bend in road, on west edge of road, near small drain, in large log; copper nail, painted "3,067.9".. 3,067.80

Primary leveling by E. E. Harris in 1921:

East on highways from Union to point near Hollywood.

Union, 3.0 miles east of, 1.0 mile west of **Keenan,** 400 feet east of T road south, in west face of north end of stone foundation of **Schley Schoolhouse;** bronze tablet stamped "H 13 1921 W. Va."..... 2,287.390

Witness Bench Mark, 23.9 feet N. 40° E., in south root of 10-inch tree; copper nail and washer..... 2,285.80

Keenan, just east of post-office, in forks of road, in southeast corner of wooden bridge; copper nail and washer, marked on fence railing "T. B. M. 2,317.6" 2,317.43

Keenan, 1.0 mile northeast of, on east side of road, in line with T road west, in east end of box culvert; copper nail and washer, marked on fence post "T. B. M. 2,439" 2,438.82

At Ronceverte.

Ronceverte, at northeast corner of concrete walk to Chesapeake and Ohio Railroad station, in angle of walk; chiseled square..... 1,666.03

WAITEVILLE QUADRANGLE: MONROE COUNTY.

(Latitude 37°15′-37°30′; Longitude 80°15′-80°30′.)

Primary leveling by C. F. Shalibo in 1920:

From point 3.0 miles east of Waiteville in Ronceverte Quadrangle along highways southwest to Waiteville, thence north into Ronceverte Quadrangle.

Waiteville, 1.3 miles east of, on Potts Valley Railroad, at southwest corner of railroad bridge 2432, 70 feet east of mile-post 27, in wooden support; copper nail, painted "2,170.8" 2,170.72

Waiteville, 1.0 mile east of, on Potts Valley Railroad, at northeast corner of railroad bridge 2431, 160 feet east of road crossing of Gap Mills road, in wooden abutment; copper nail, painted "2,173.0"..... 2,172.89

Waiteville, 1.5 miles north of, on road to Gap Mills, 60 feet west of road, in front of L. W. McCormick's residence, at front door-step, in cement walk; bronze tablet stamped "W. Va. 1920 2,212"..... 2,212.013

Waiteville, 3.0 miles north of, on road to Gap Mills, at road forks of T road west, in northwest corner of forks, in root of small tree; copper nail, painted "2,630.2" 2,630.08

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